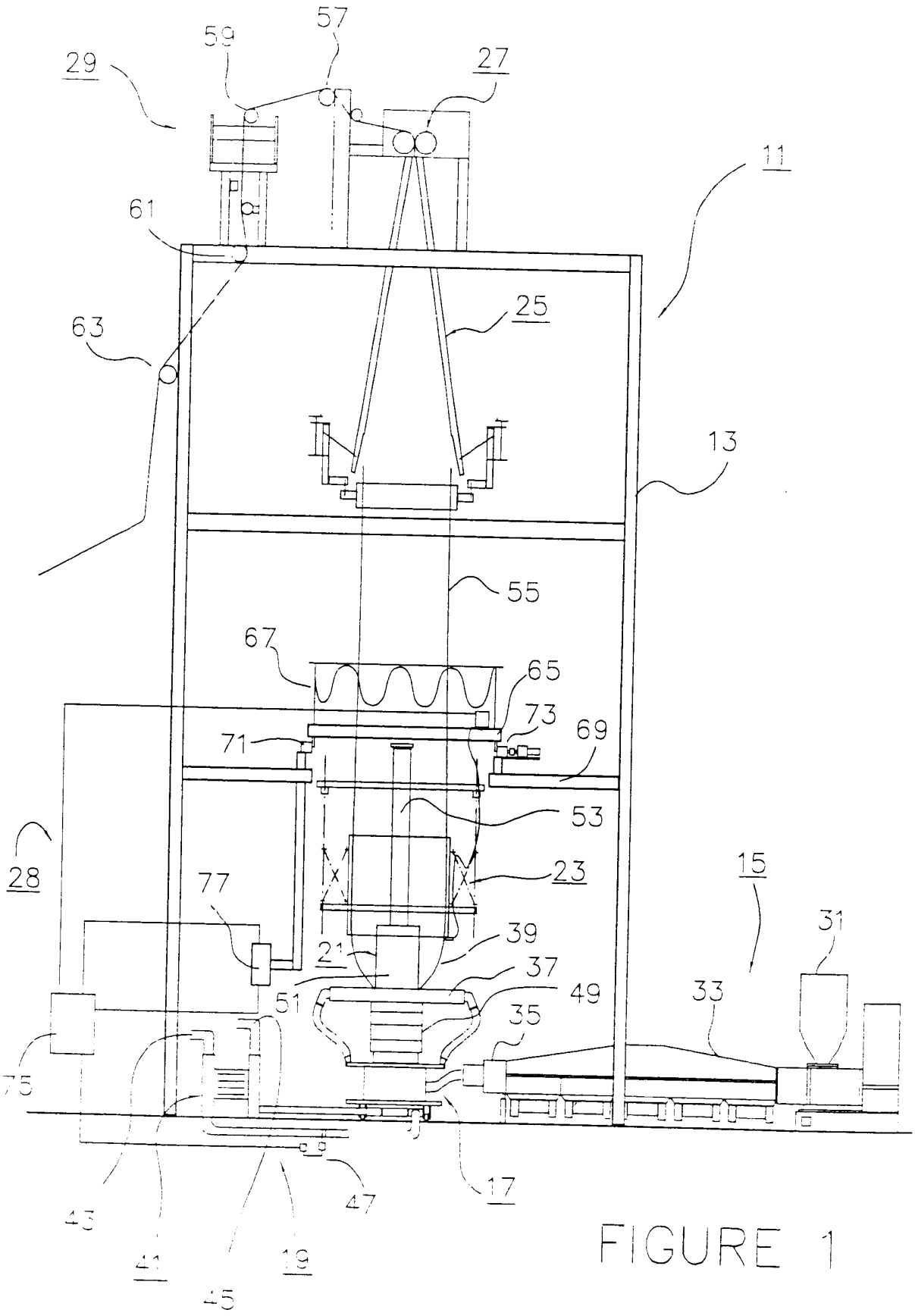

57
59
29
27
11
61
25
63
13
55
67
65
73
69
71
53
28
23
15
77
31
39
21
37
49
51
33
35
75
17
47
43
41
19
45

FIGURE 1

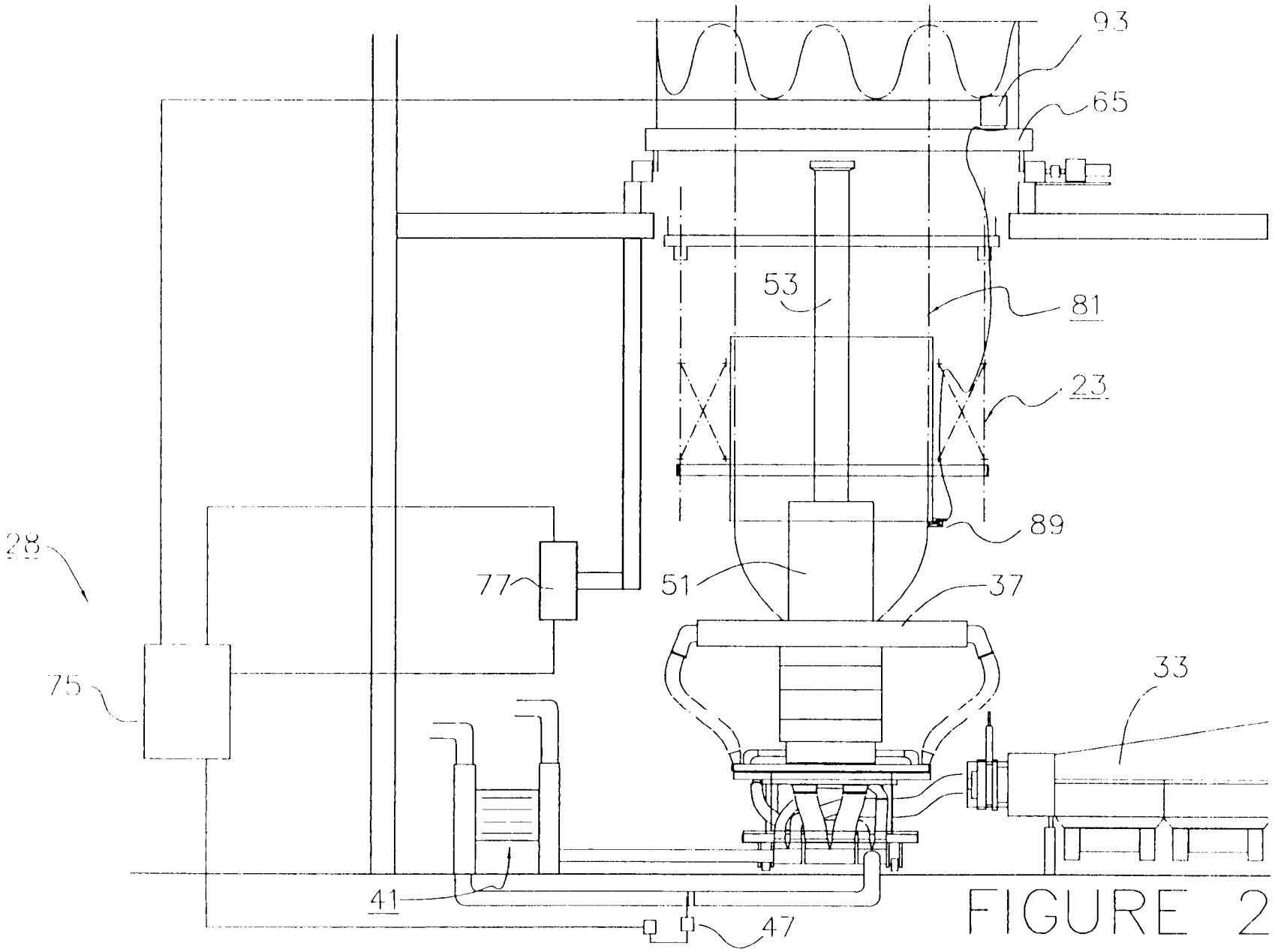


FIGURE 2

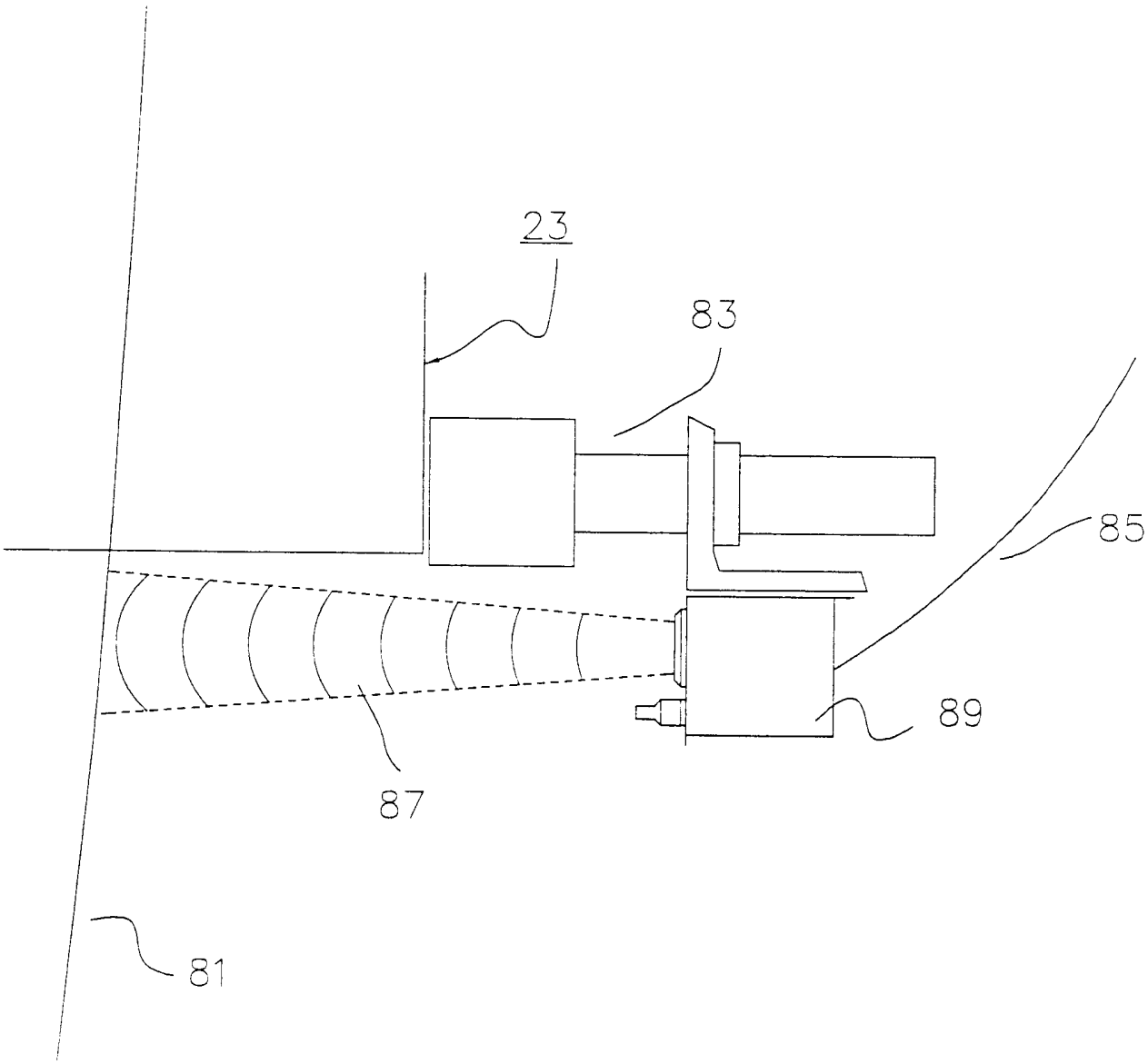


FIGURE 3

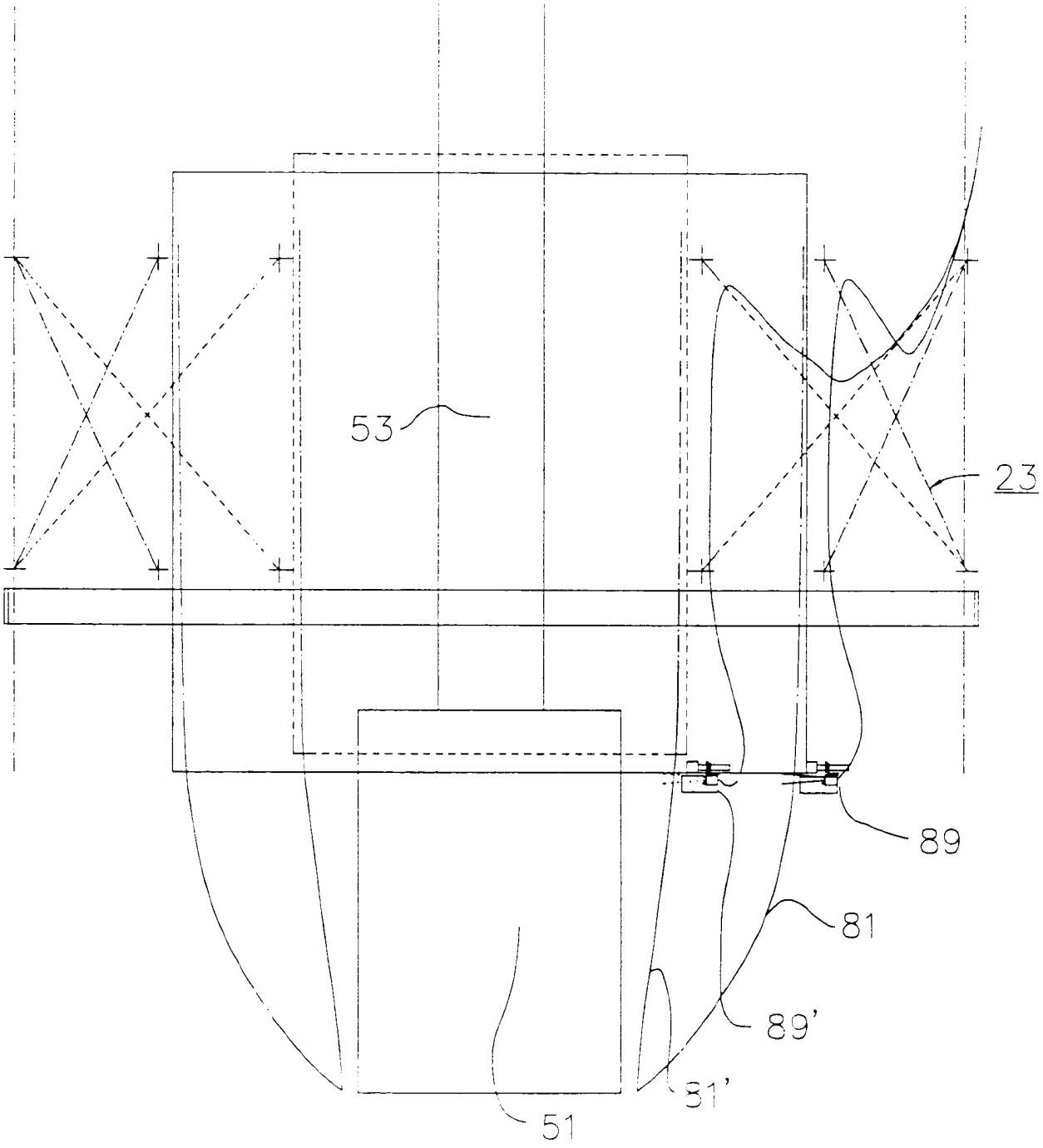


FIGURE 4

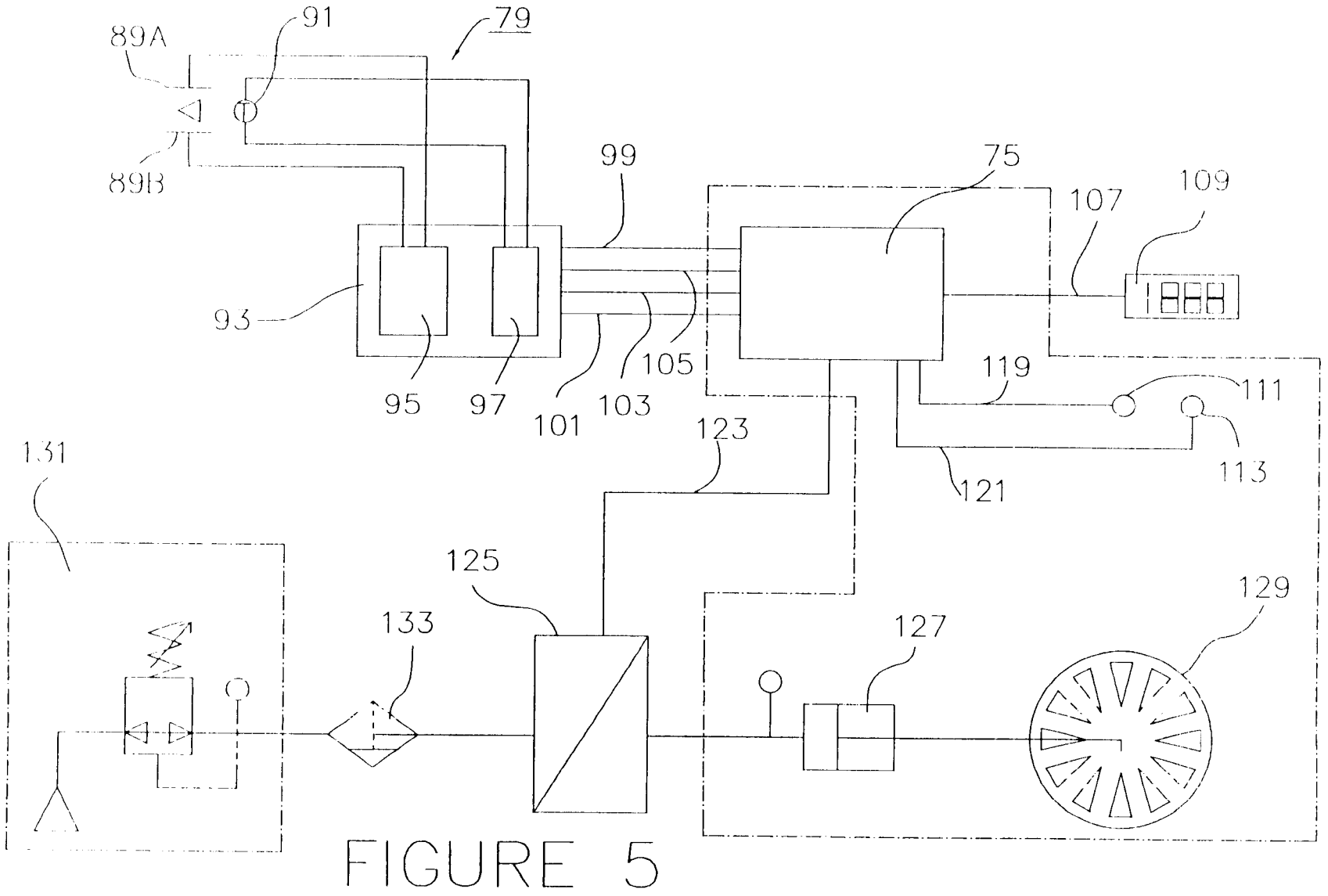

89A
91
79
89B
99
75
107
109
93
95
97
101
103
105
119
111
113
123
121
131
125
133
127
129

FIGURE 5

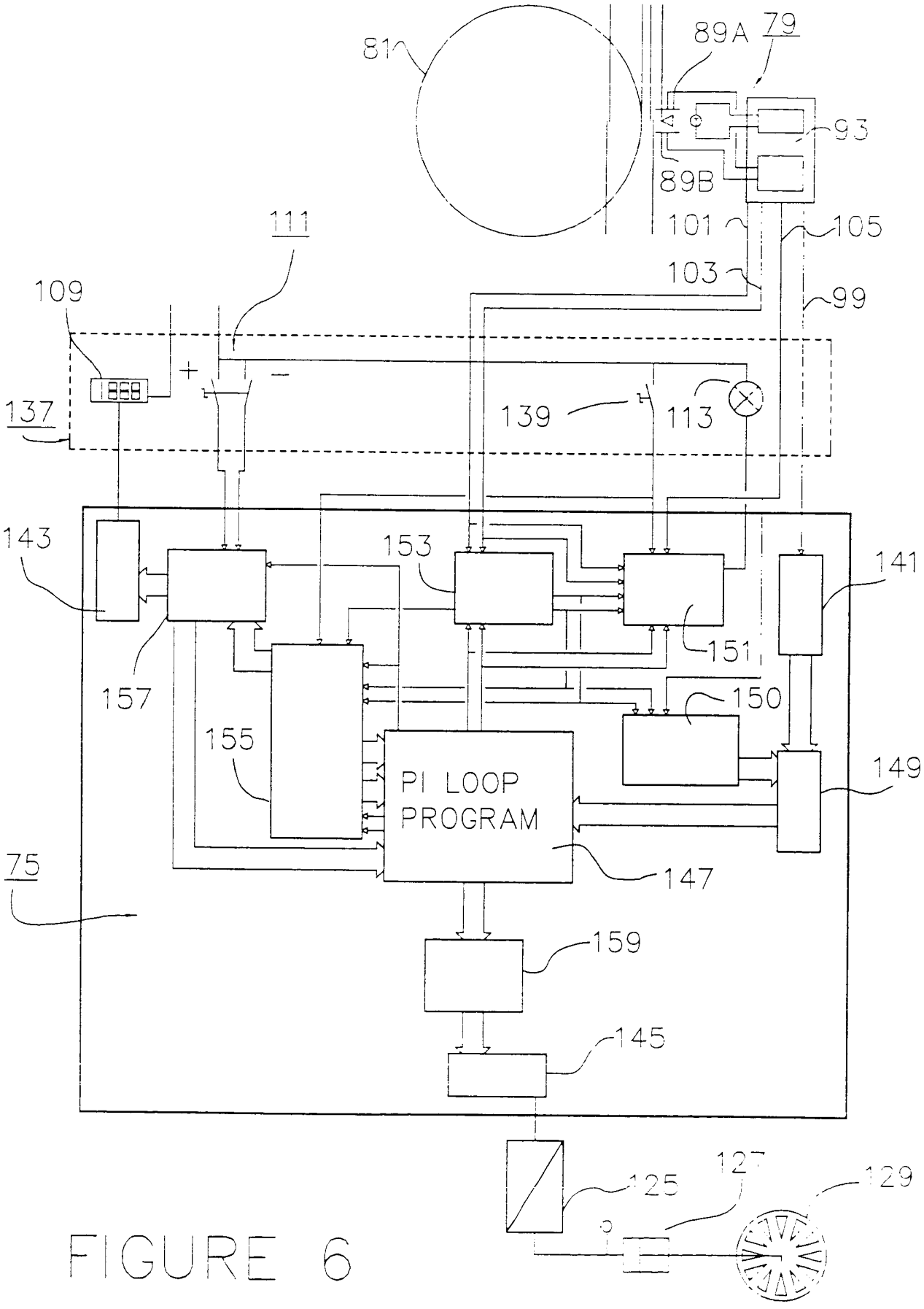

81
89A
79
93
89B
101
105
111
103
99
109
137
139
113
143
153
141
151
157
150
155
PI LOOP
PROGRAM
149
75
147
159
145
125
127
129

FIGURE 6

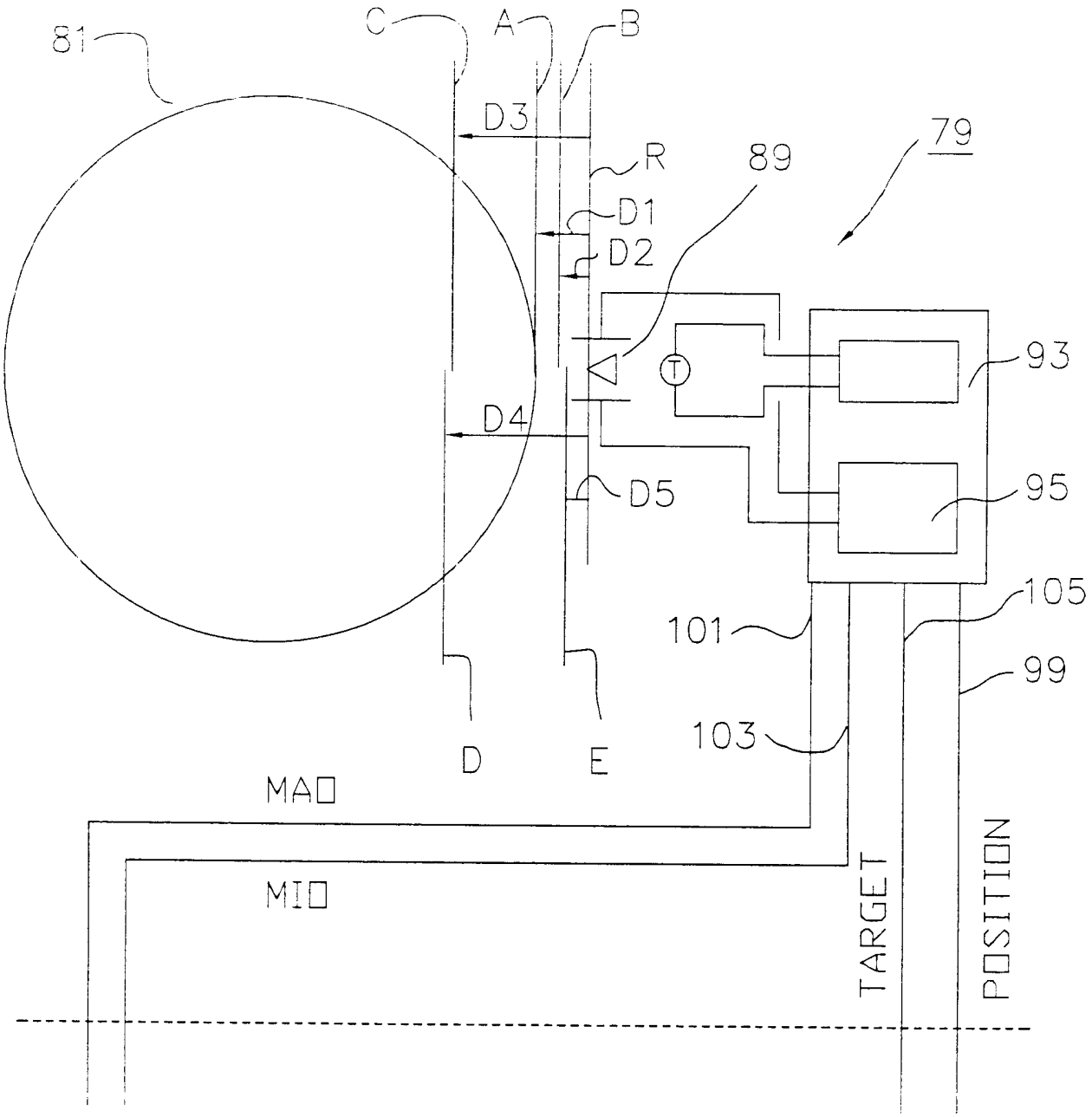

81
C
A
B
D3
R
89
79
D1
D2
93
D4
95
D5
105
101
99
103
D
E
MA□
MI□
TARGET
POSITION

FIGURE 7A

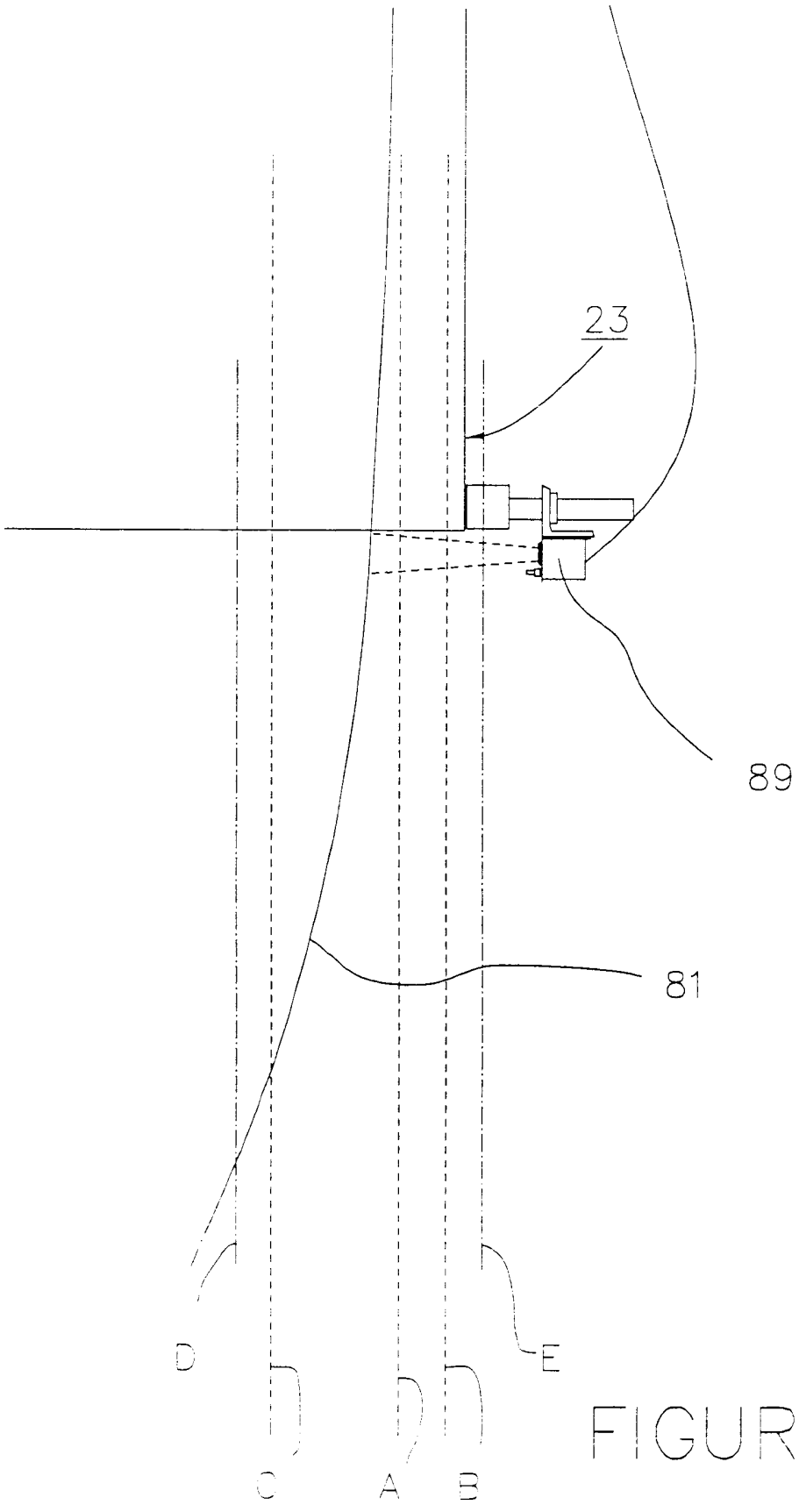


FIGURE 7B

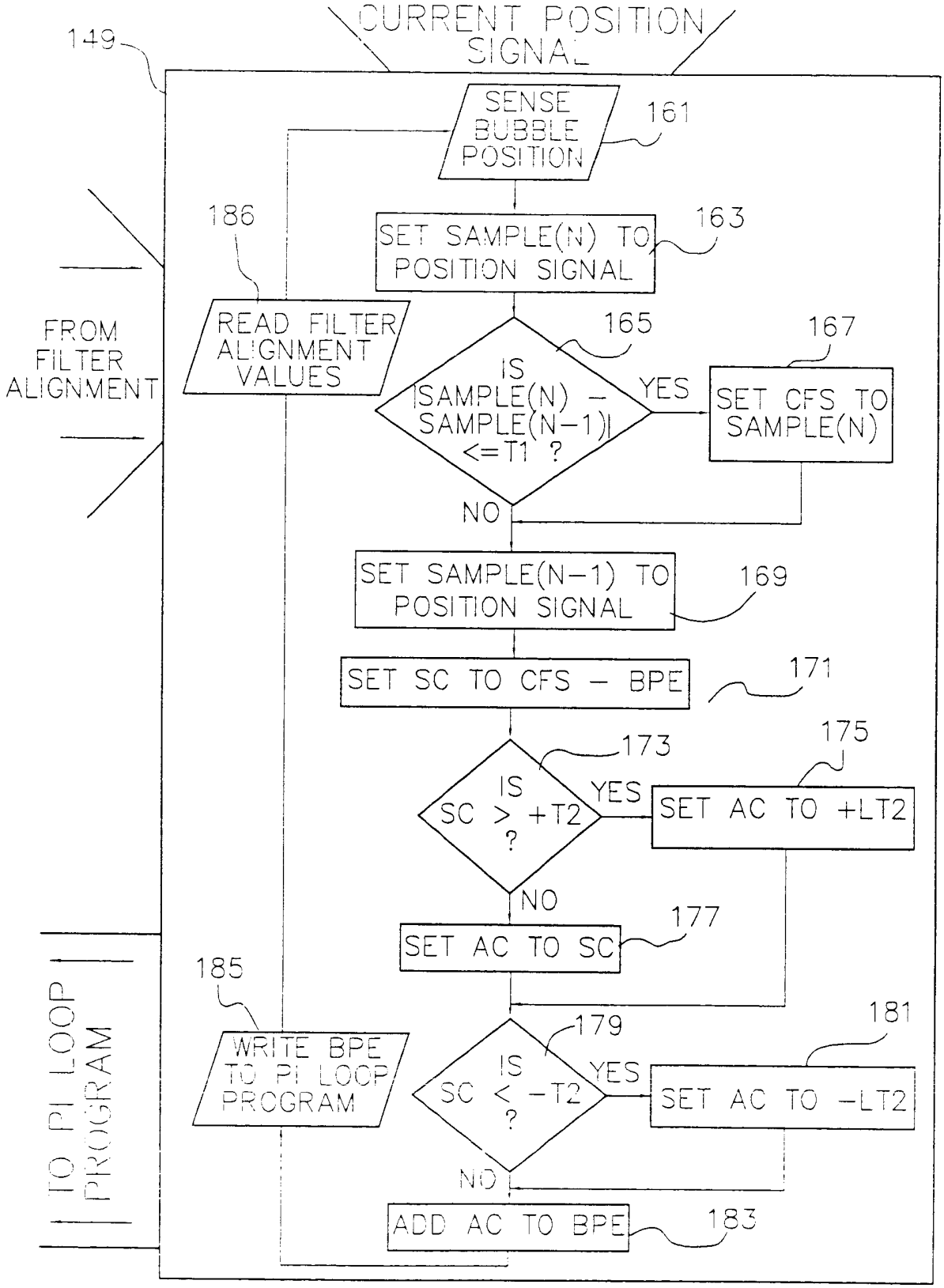

149
CURRENT POSITION SIGNAL
SENSE BUBBLE POSITION
161
SET SAMPLE(N) TO POSITION SIGNAL
163
186
READ FILTER ALIGNMENT VALUES
FROM FILTER ALIGNMENT
165
IS |SAMPLE(N) − SAMPLE(N−1)| <=T1 ?
YES
167
SET CFS TO SAMPLE(N)
NO
SET SAMPLE(N−1) TO POSITION SIGNAL
169
SET SC TO CFS − BPE
171
173
IS SC > +T2 ?
YES
175
SET AC TO +LT2
NO
SET AC TO SC
177
185
WRITE BPE TO PI LOOP PROGRAM
179
IS SC < −T2 ?
YES
181
SET AC TO −LT2
NO
ADD AC TO BPE
183
TO PI LOOP PROGRAM

FIGURE 8A

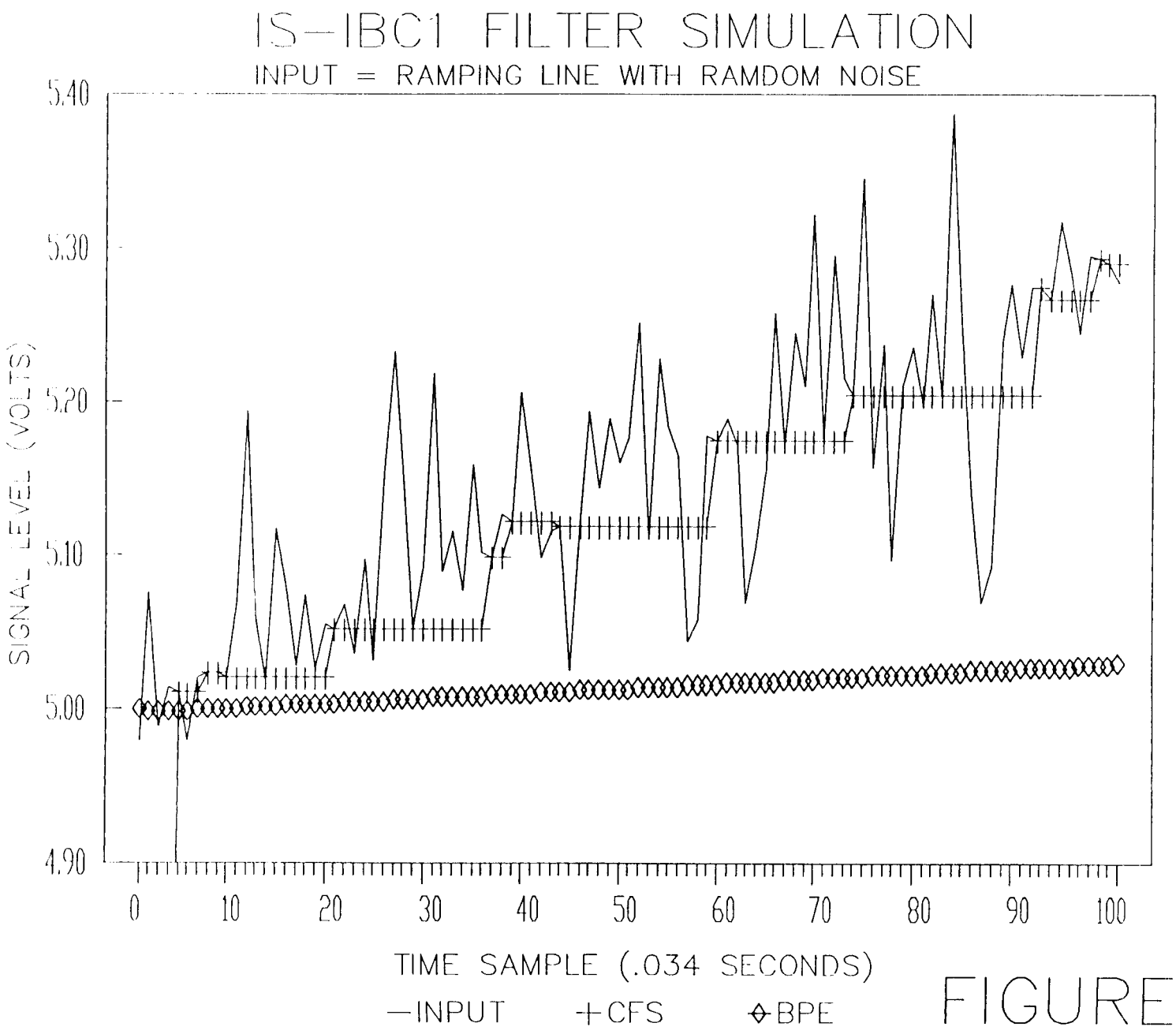

IS-IBC1 FILTER SIMULATION
INPUT = RAMPING LINE WITH RAMDOM NOISE
SIGNAL LEVEL (VOLTS)
5.40
5.30
5.20
5.10
5.00
4.90
0
10
20
30
40
50
60
70
80
90
100
TIME SAMPLE (.034 SECONDS)
—INPUT
+CFS
◇BPE

FIGURE 8B

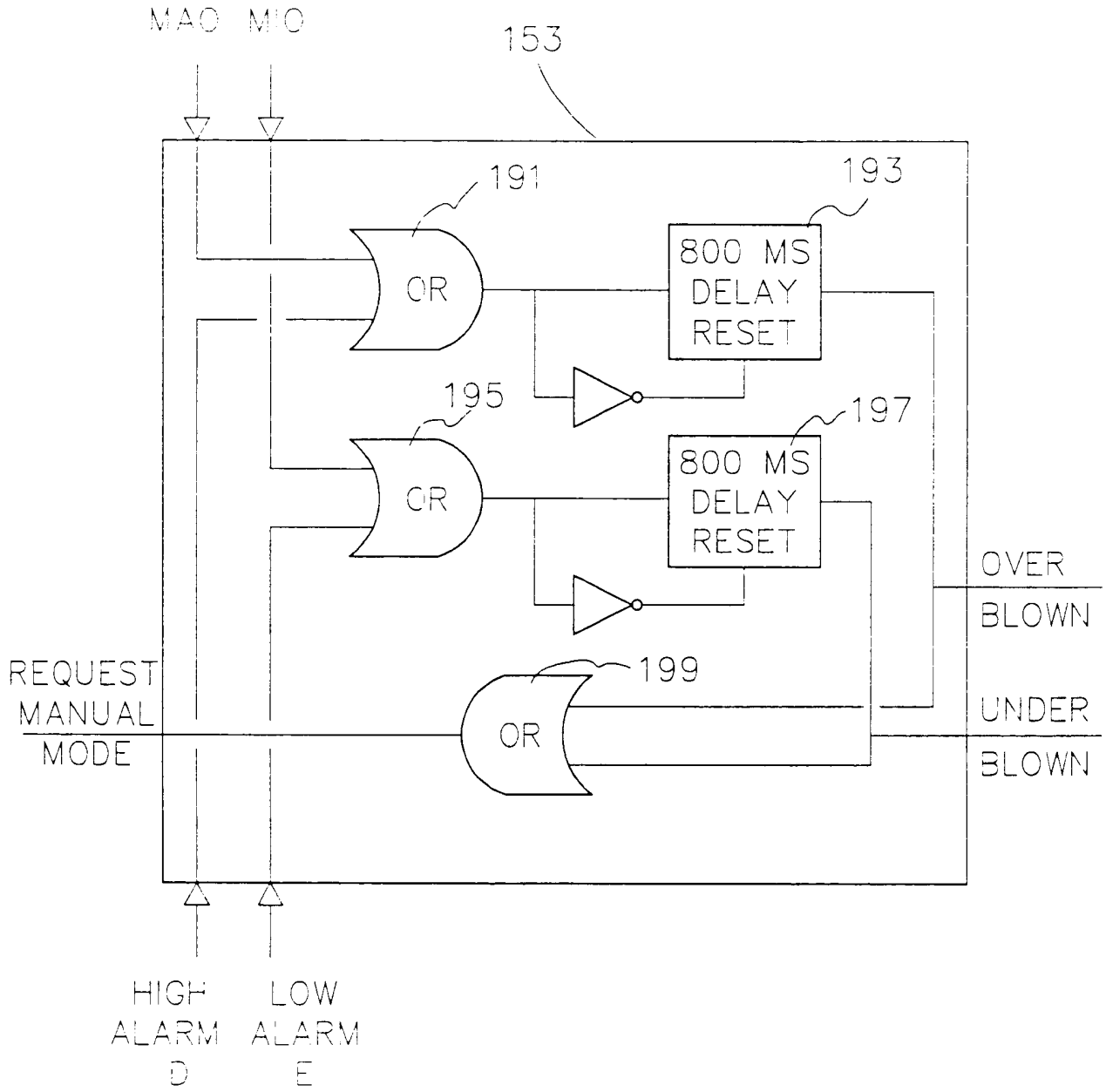

MAO
MIO
153
191
193
OR
800 MS
DELAY
RESET
195
197
OR
800 MS
DELAY
RESET
OVER
BLOWN
REQUEST
MANUAL
MODE
199
OR
UNDER
BLOWN
HIGH
ALARM
D
LOW
ALARM
E

FIGURE 9

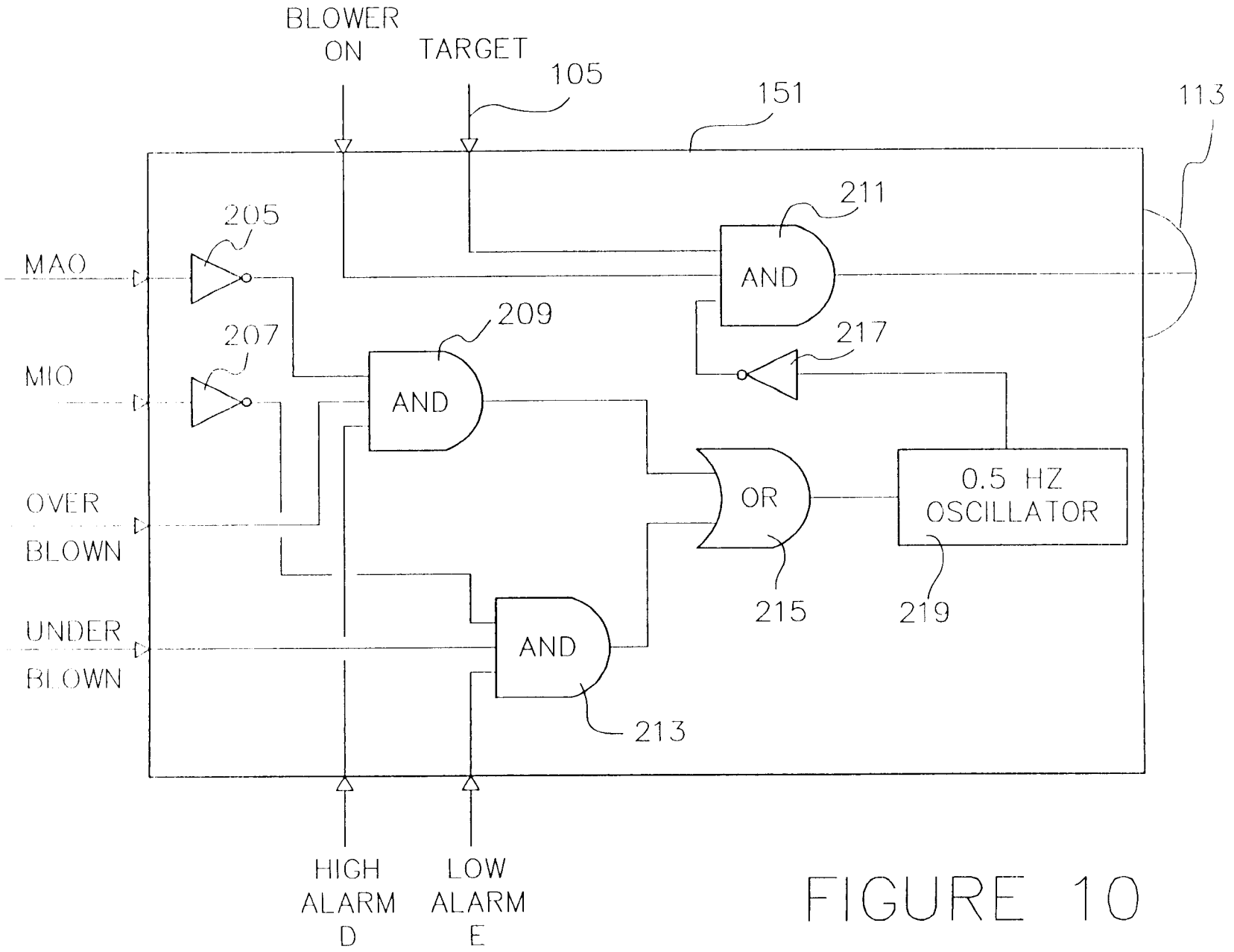

BLOWER ON
TARGET
105
151
113
205
211
MAO
AND
209
207
217
MIO
AND
OVER BLOWN
OR
0.5 HZ OSCILLATOR
UNDER BLOWN
AND
215
219
213
HIGH ALARM D
LOW ALARM E

FIGURE 10

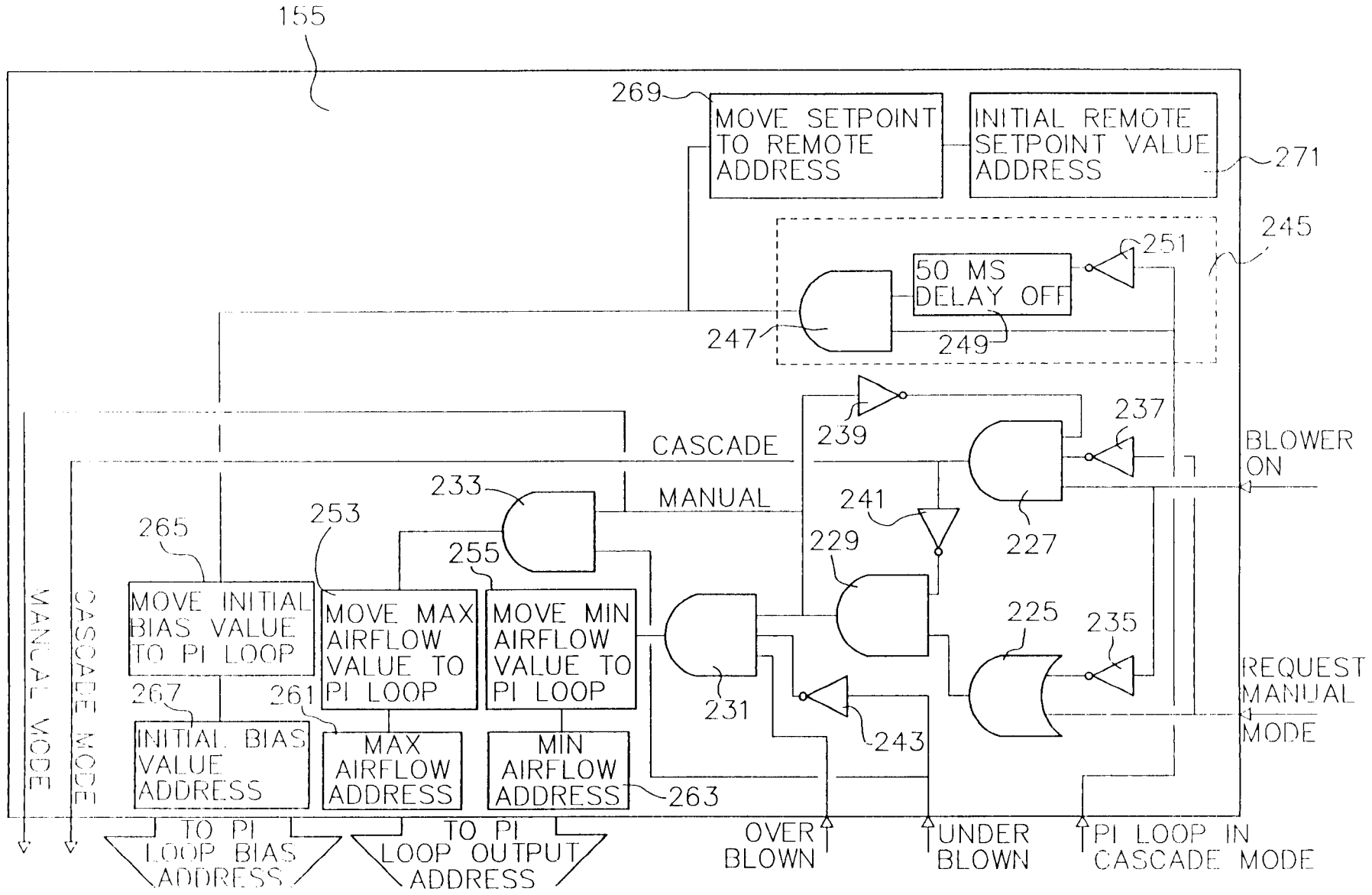

155
269
MOVE SETPOINT TO REMOTE ADDRESS
INITIAL REMOTE SETPOINT VALUE ADDRESS
271
245
251
50 MS DELAY OFF
247
249
239
237
CASCADE
MANUAL
BLOWER ON
233
241
265
253
255
229
227
MOVE INITIAL BIAS VALUE TO PI LOOP
MOVE MAX AIRFLOW VALUE TO PI LOOP
MOVE MIN AIRFLOW VALUE TO PI LOOP
225
235
231
267
261
243
REQUEST MANUAL MODE
INITIAL BIAS VALUE ADDRESS
MAX AIRFLOW ADDRESS
MIN AIRFLOW ADDRESS
263
MANUAL MODE
CASCADE MODE
TO PI LOOP BIAS ADDRESS
TO PI LOOP OUTPUT ADDRESS
OVER BLOWN
UNDER BLOWN
PI LOOP IN CASCADE MODE

FIGURE 11

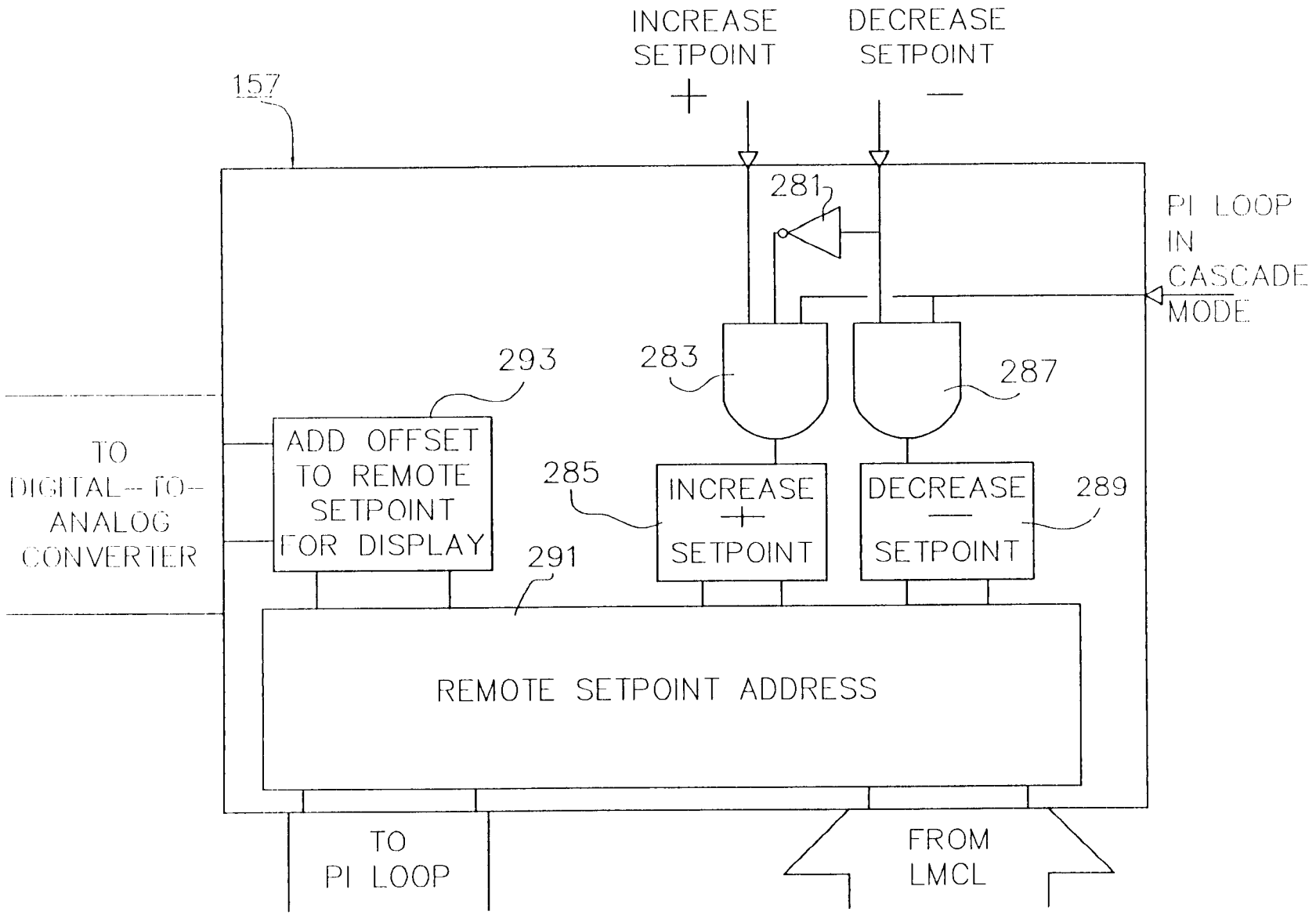

INCREASE SETPOINT
+
DECREASE SETPOINT
—
157
281
PI LOOP IN CASCADE MODE
293
283
287
TO DIGITAL-TO-ANALOG CONVERTER
ADD OFFSET TO REMOTE SETPOINT FOR DISPLAY
285
INCREASE + SETPOINT
DECREASE — SETPOINT
289
291
REMOTE SETPOINT ADDRESS
TO PI LOOP
FROM LMCL

FIGURE 12

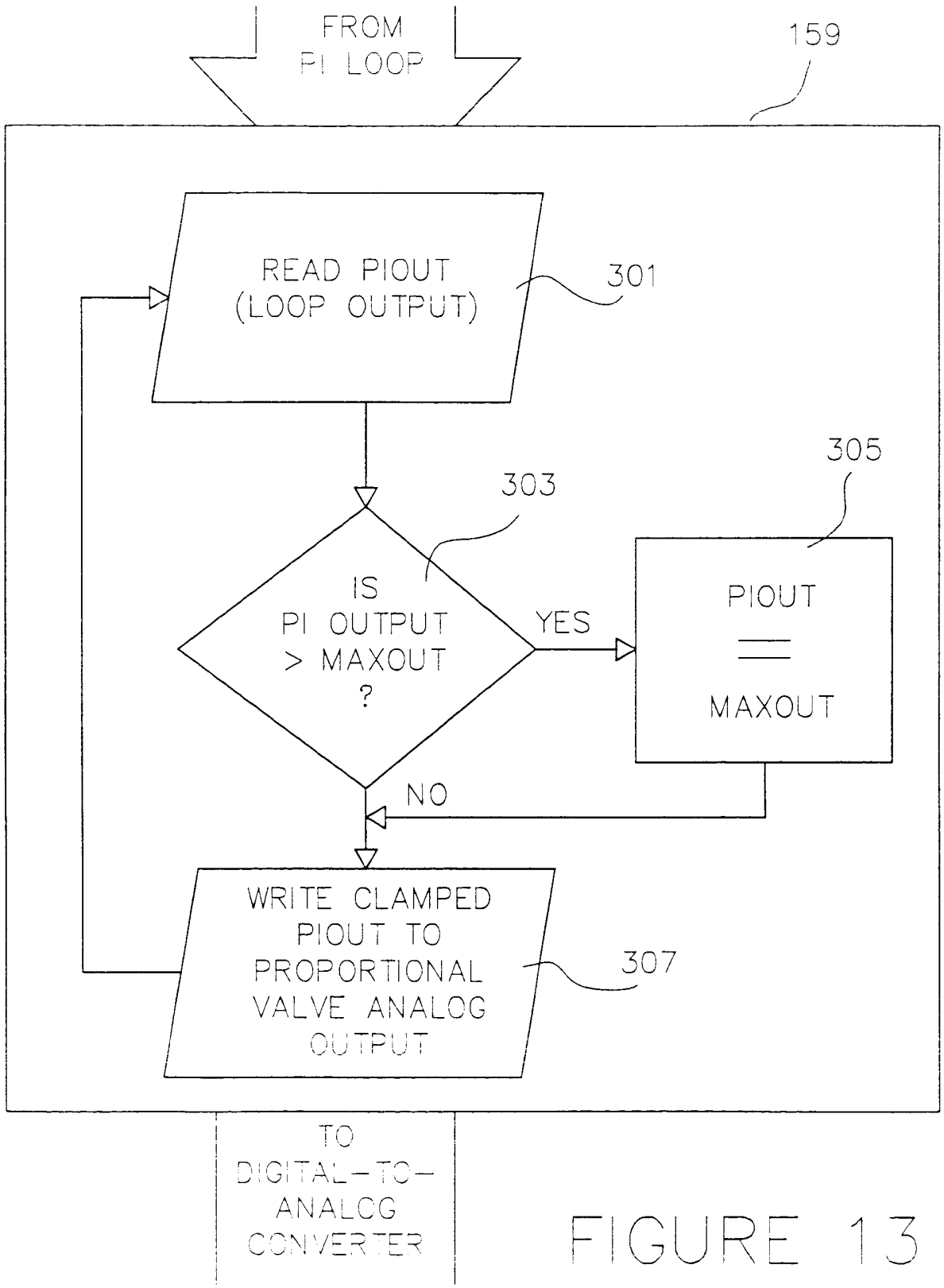

FROM
PI LOOP
159
READ PIOUT
(LOOP OUTPUT)
301
303
IS
PI OUTPUT
> MAXOUT
?
YES
305
PIOUT
=
MAXOUT
NO
WRITE CLAMPED
PIOUT TO
PROPORTIONAL
VALVE ANALOG
OUTPUT
307
TO
DIGITAL-TO-
ANALOG
CONVERTER

FIGURE 13

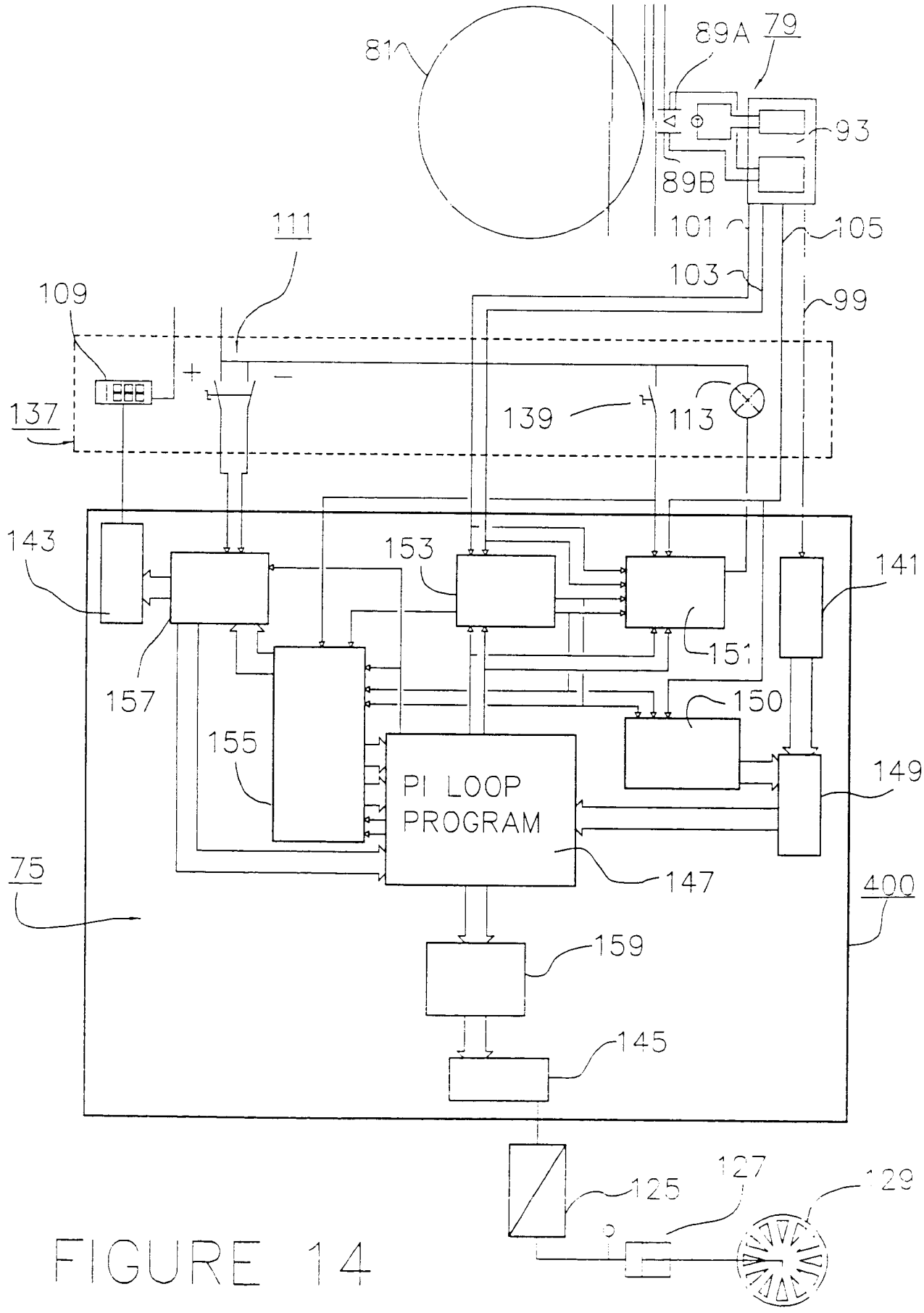

81
89A
79
93
89B
101
105
111
103
99
109
137
139
113
143
153
141
151
157
150
155
PI LOOP
PROGRAM
149
75
147
400
159
145
125
127
129

FIGURE 14

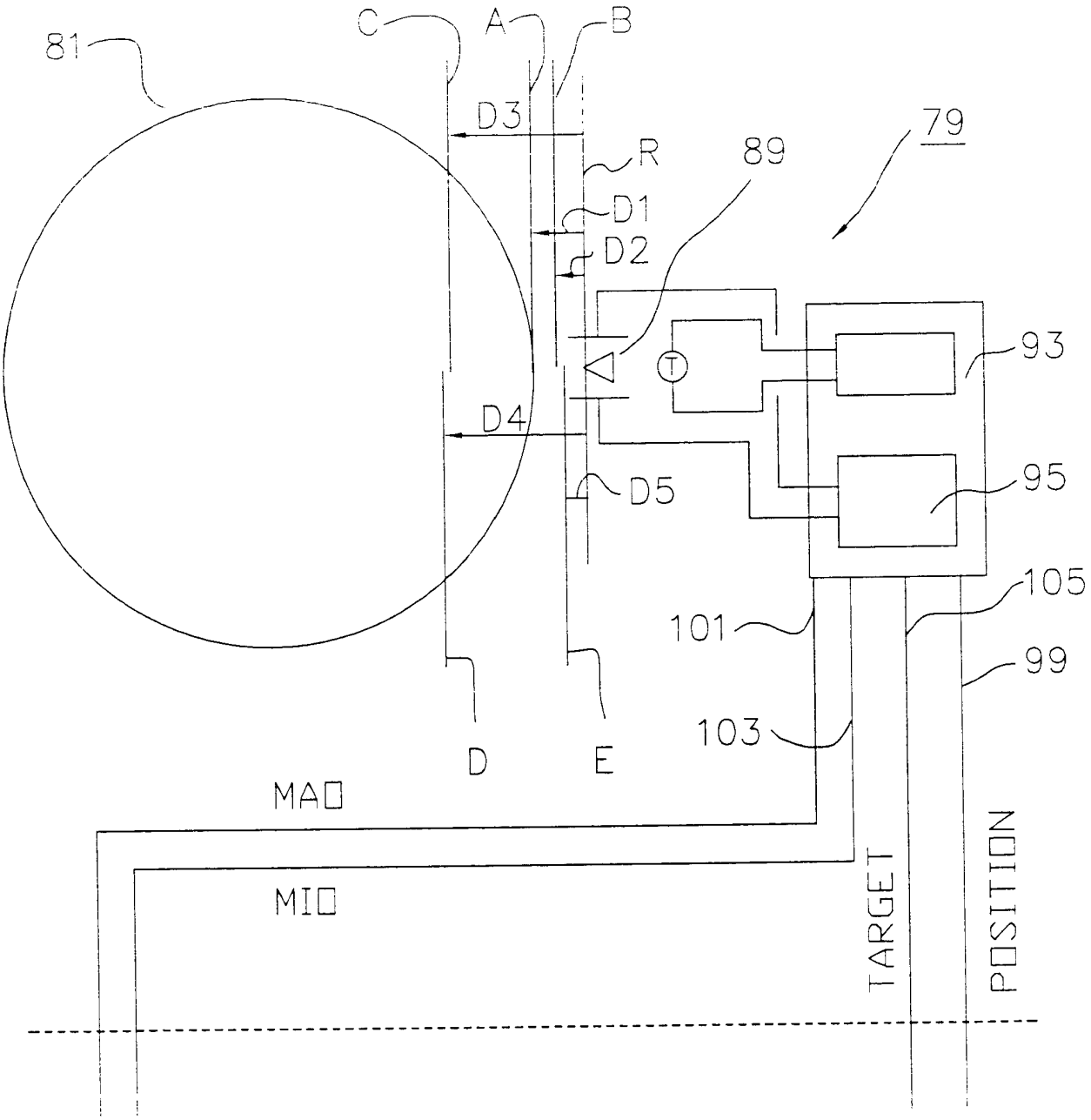

81
C
A
B
D3
R
89
79
D1
D2
93
D4
95
D5
105
101
99
103
D
E
MA□
MI□
TARGET
POSITION

FIGURE 15

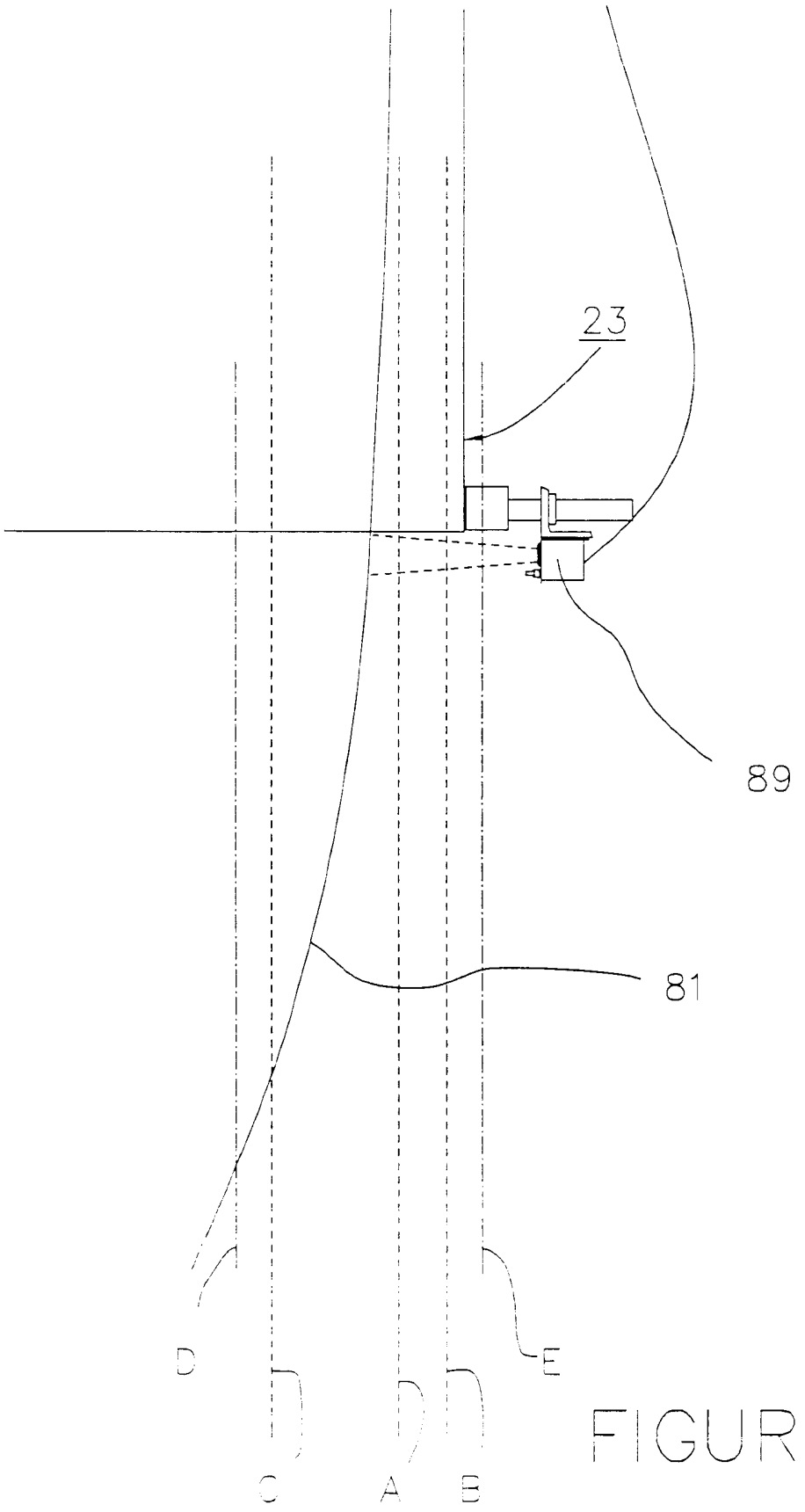


FIGURE 16

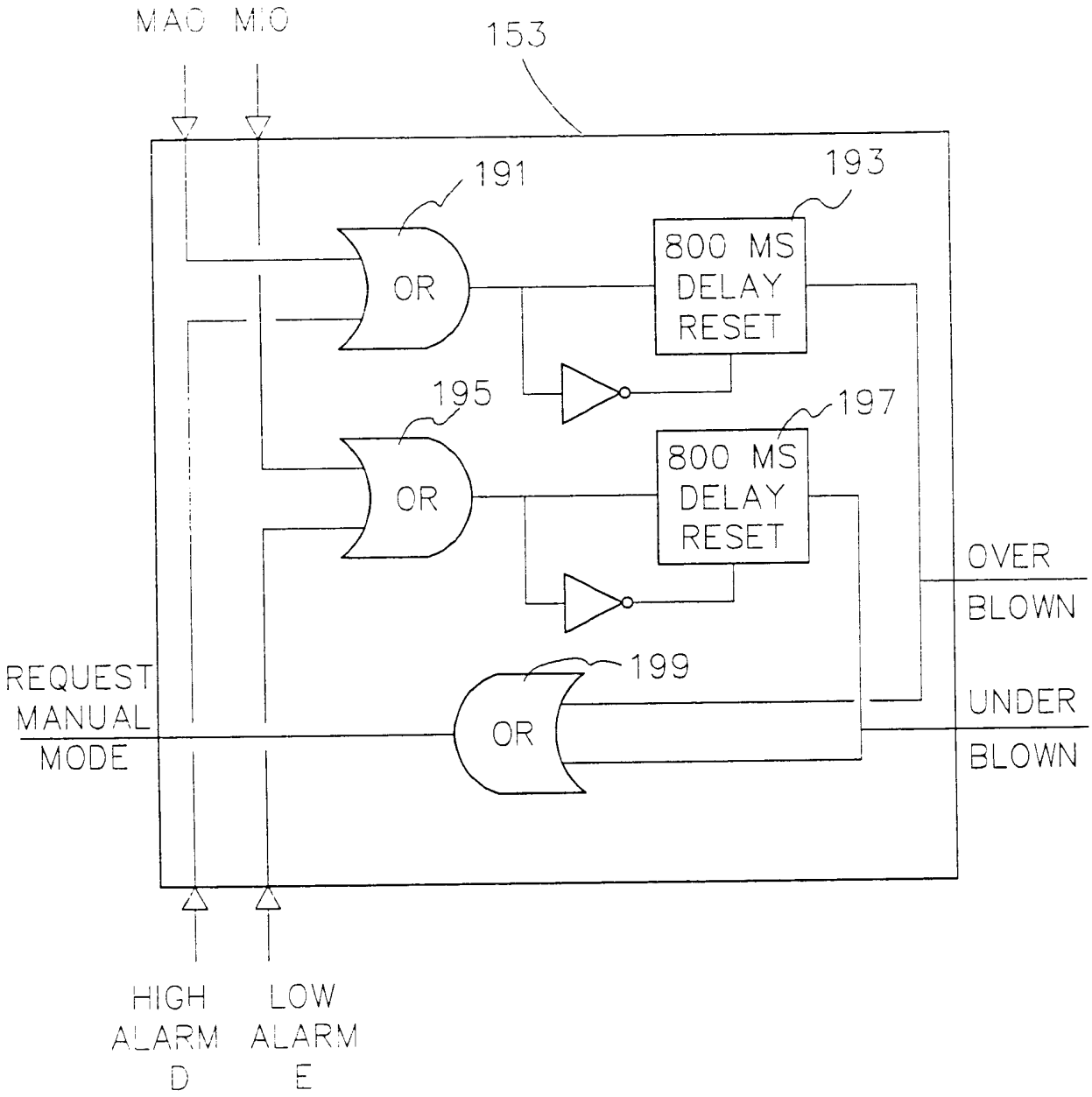

MAC
MIC
153
191
193
OR
800 MS
DELAY
RESET
195
197
OR
800 MS
DELAY
RESET
OVER
BLOWN
REQUEST
MANUAL
MODE
199
OR
UNDER
BLOWN
HIGH
ALARM
D
LOW
ALARM
E

FIGURE 17

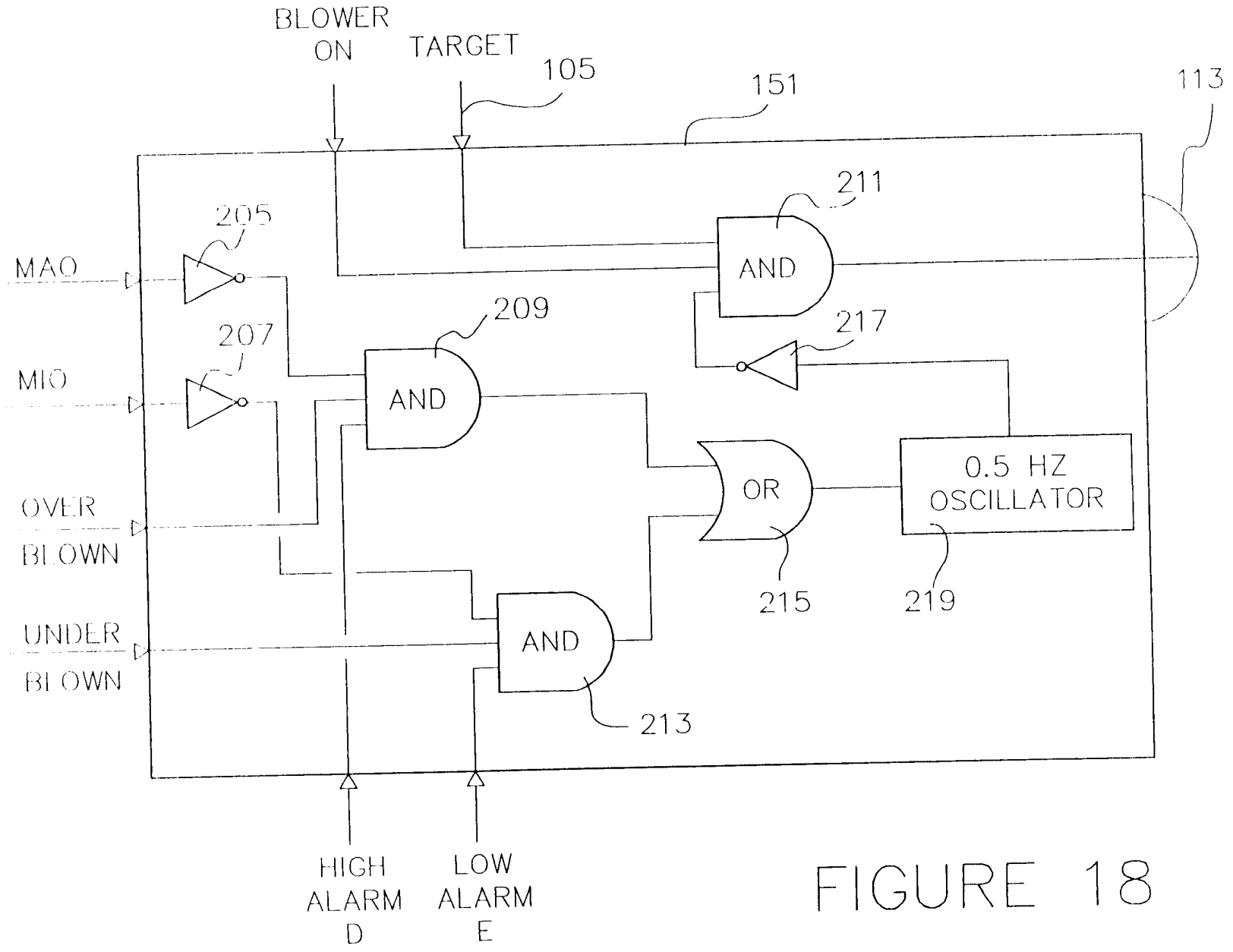

BLOWER ON
TARGET
105
151
113
211
205
MAO
AND
209
207
217
MIO
AND
OR
0.5 HZ OSCILLATOR
OVER BLOWN
215
219
UNDER BLOWN
AND
213
HIGH ALARM D
LOW ALARM E

FIGURE 18

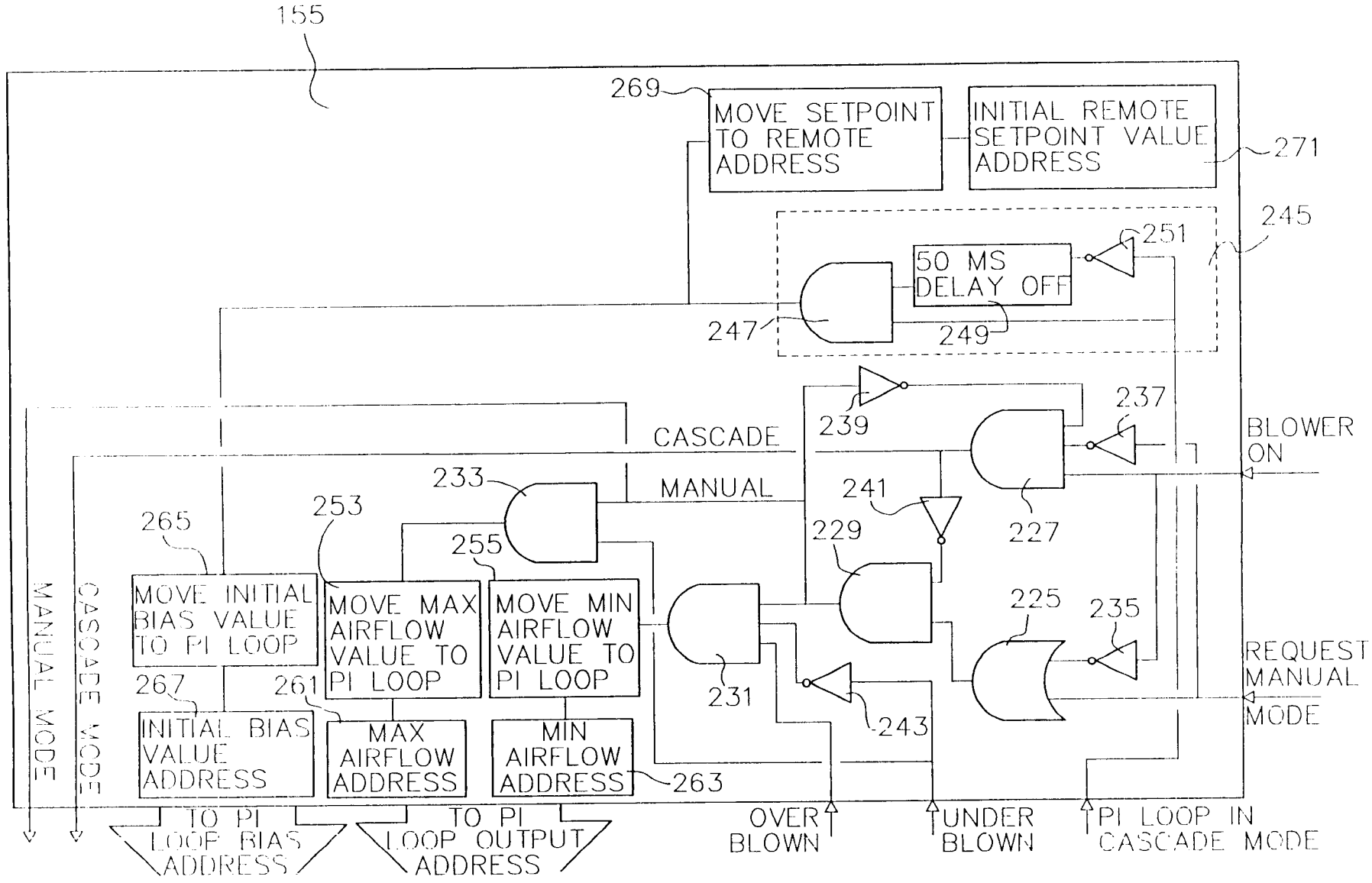

155
269
MOVE SETPOINT TO REMOTE ADDRESS
INITIAL REMOTE SETPOINT VALUE ADDRESS
271
245
251
50 MS DELAY OFF
247
249
239
237
CASCADE
BLOWER ON
233
MANUAL
241
253
265
255
229
227
MOVE INITIAL BIAS VALUE TO PI LOOP
MOVE MAX AIRFLOW VALUE TO PI LOOP
MOVE MIN AIRFLOW VALUE TO PI LOOP
225
235
231
243
REQUEST MANUAL MODE
267
261
INITIAL BIAS VALUE ADDRESS
MAX AIRFLOW ADDRESS
MIN AIRFLOW ADDRESS
263
MANUAL MODE
CASCADE MODE
TO PI LOOP BIAS ADDRESS
TO PI LOOP OUTPUT ADDRESS
OVER BLOWN
UNDER BLOWN
PI LOOP IN CASCADE MODE

FIGURE 19

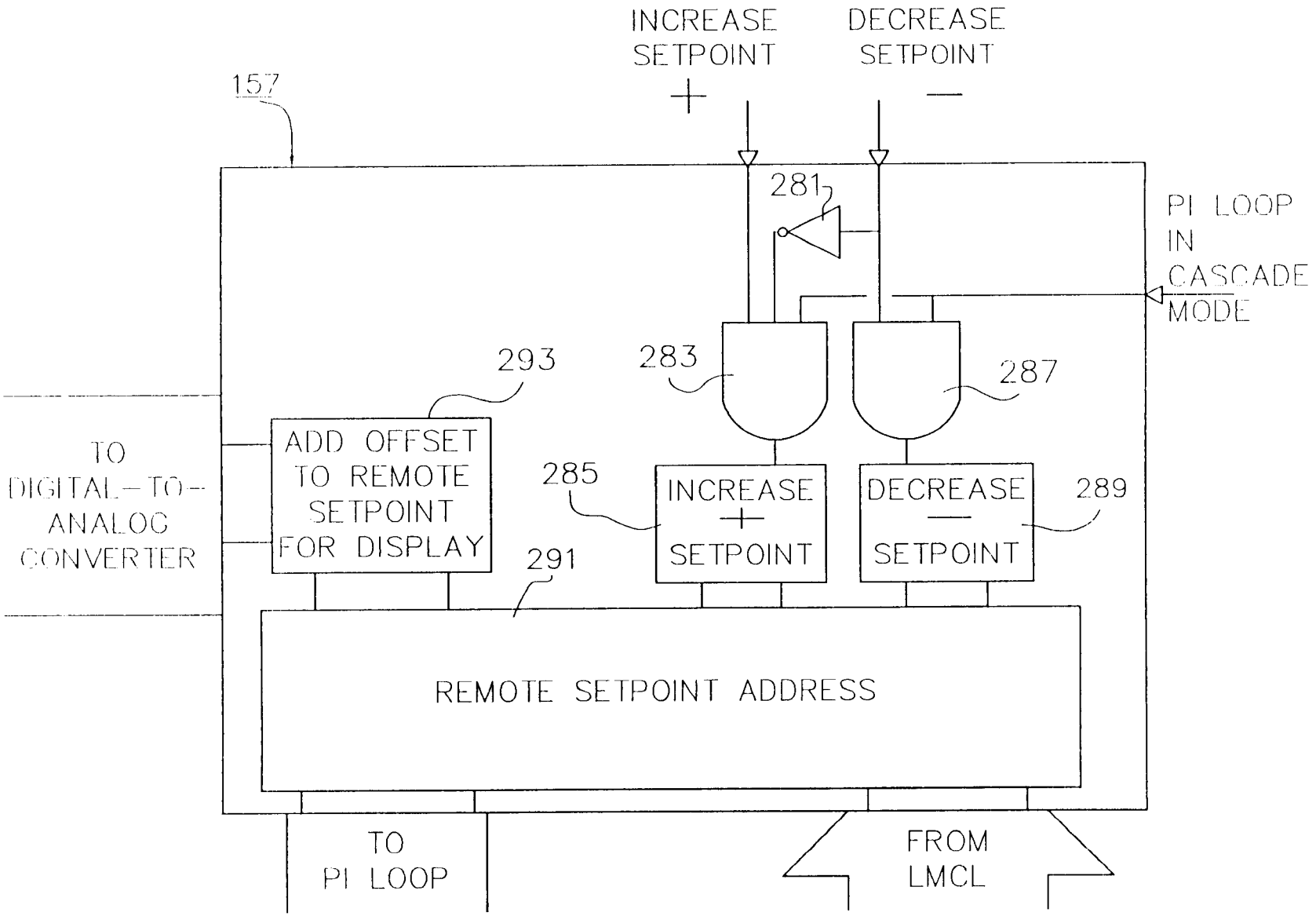

INCREASE SETPOINT
+
DECREASE SETPOINT
−
157
281
PI LOOP IN CASCADE MODE
293
283
287
TO DIGITAL-TO-ANALOG CONVERTER
ADD OFFSET TO REMOTE SETPOINT FOR DISPLAY
285
INCREASE + SETPOINT
DECREASE − SETPOINT
289
291
REMOTE SETPOINT ADDRESS
TO PI LOOP
FROM LMCL

FIGURE 20

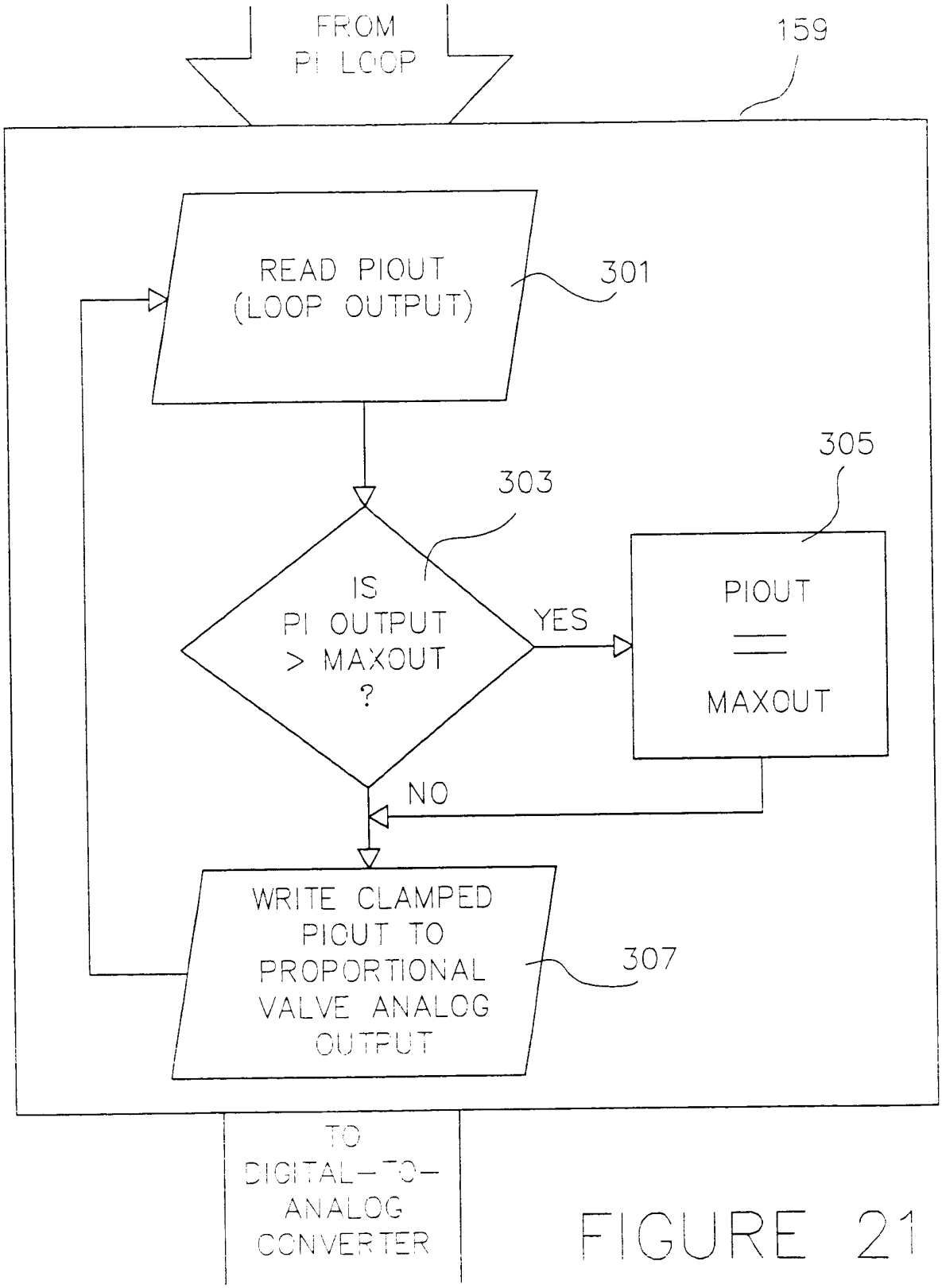

FROM
PI LOOP
159
READ PIOUT
(LOOP OUTPUT)
301
303
IS
PI OUTPUT
> MAXOUT
?
YES
305
PIOUT
=
MAXOUT
NO
WRITE CLAMPED
PIOUT TO
PROPORTIONAL
VALVE ANALOG
OUTPUT
307
TO
DIGITAL-TO-
ANALOG
CONVERTER

FIGURE 21

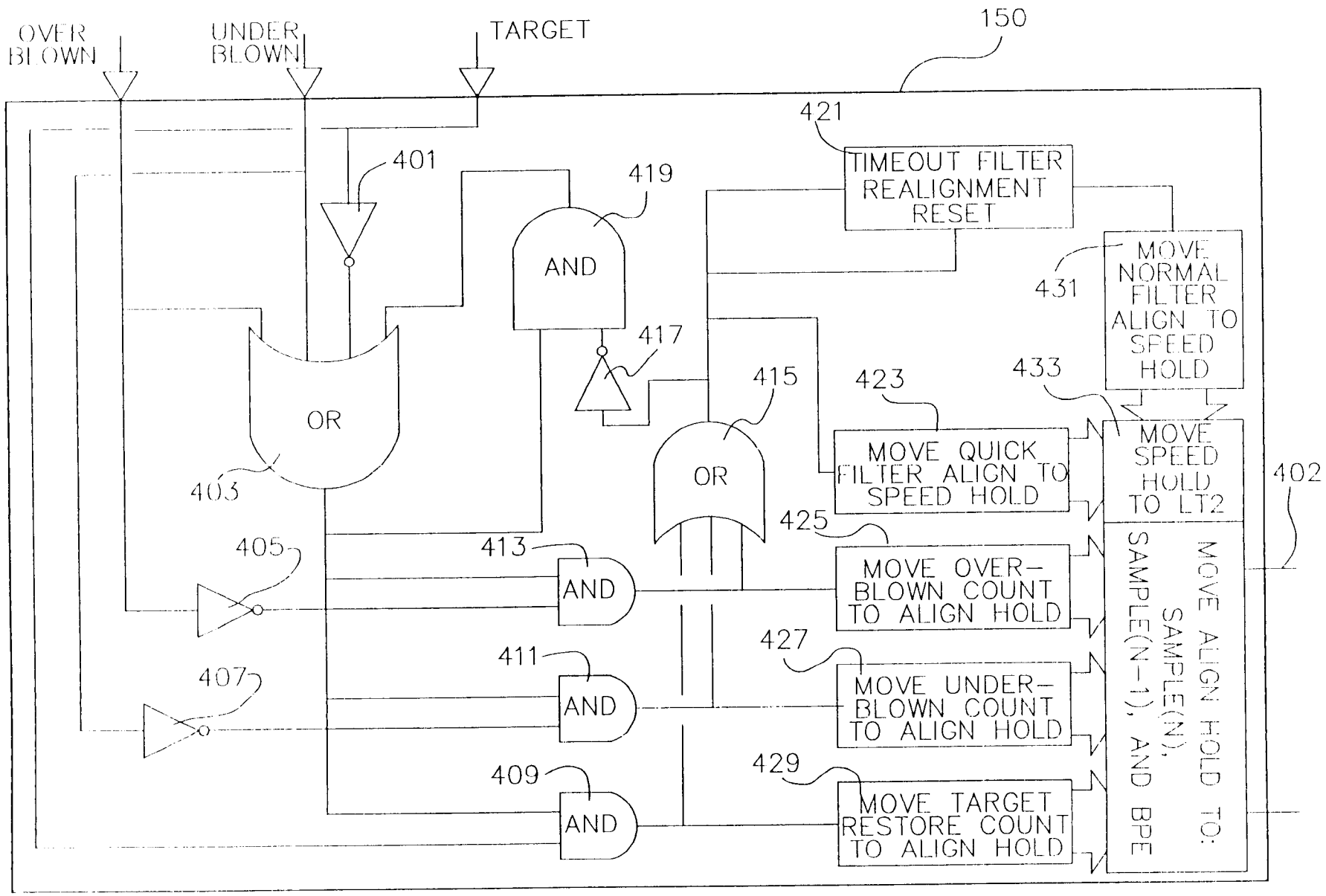

OVER BLOWN
UNDER BLOWN
TARGET
150
421
TIMEOUT FILTER REALIGNMENT RESET
401
419
AND
431
MOVE NORMAL FILTER ALIGN TO SPEED HOLD
417
415
423
433
OR
MOVE QUICK FILTER ALIGN TO SPEED HOLD
MOVE SPEED HOLD TO LT2
403
OR
402
425
405
413
AND
MOVE OVER-BLOWN COUNT TO ALIGN HOLD
427
411
407
AND
MOVE UNDER-BLOWN COUNT TO ALIGN HOLD
MOVE ALIGN HOLD TO: SAMPLE(N), SAMPLE(N-1), AND BPE
429
409
AND
MOVE TARGET RESTORE COUNT TO ALIGN HOLD

FIGURE 22

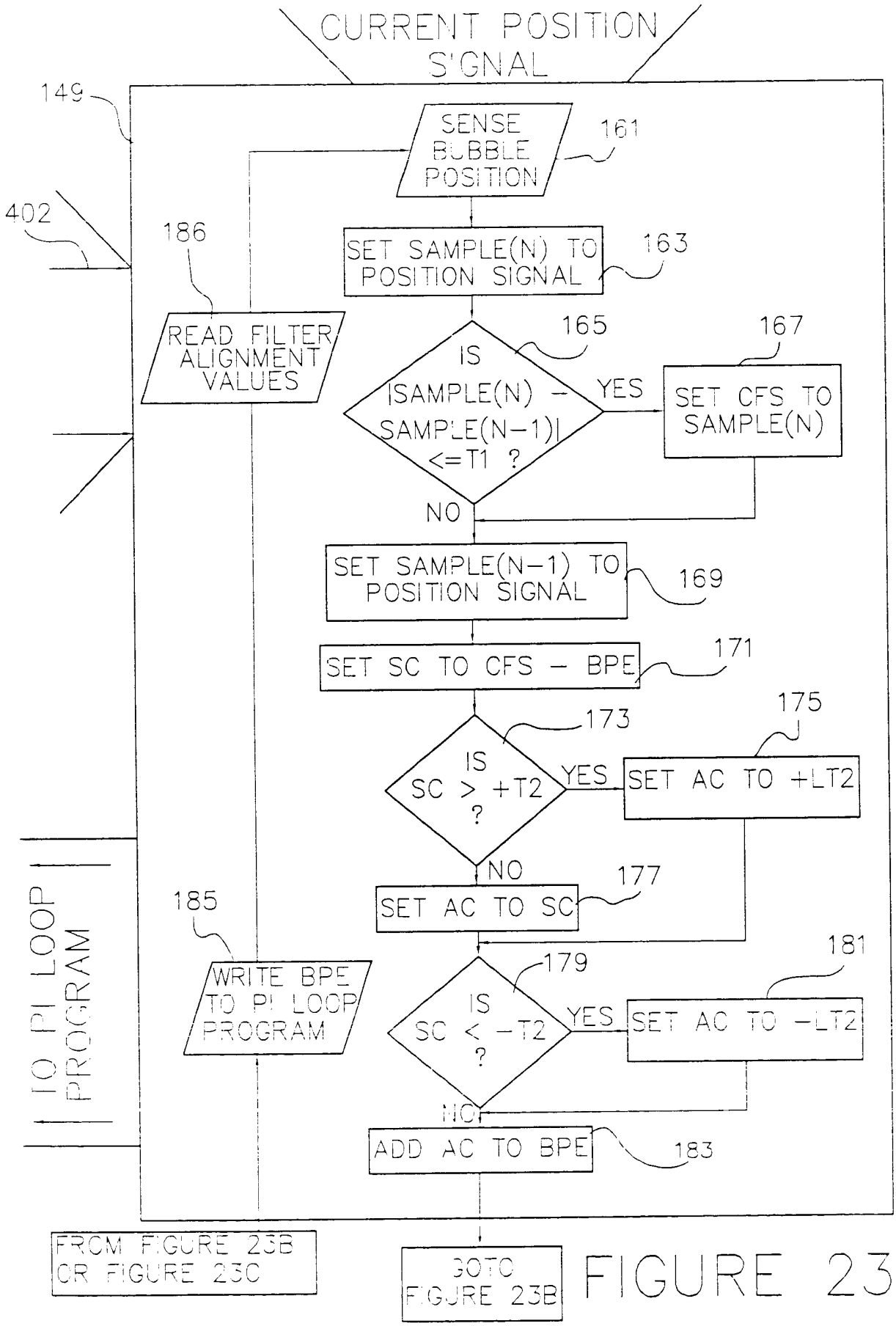

CURRENT POSITION SIGNAL
149
SENSE BUBBLE POSITION
161
402
186
SET SAMPLE(N) TO POSITION SIGNAL
163
READ FILTER ALIGNMENT VALUES
165
IS |SAMPLE(N) − SAMPLE(N−1)| <=T1 ?
YES
167
SET CFS TO SAMPLE(N)
NO
SET SAMPLE(N−1) TO POSITION SIGNAL
169
SET SC TO CFS − BPE
171
173
IS SC > +T2 ?
YES
175
SET AC TO +LT2
NO
177
SET AC TO SC
185
WRITE BPE TO PI LOOP PROGRAM
179
IS SC < −T2 ?
YES
181
SET AC TO −LT2
NO
ADD AC TO BPE
183
TO PI LOOP PROGRAM
FROM FIGURE 23B OR FIGURE 23C
GOTO FIGURE 23B

FIGURE 23A

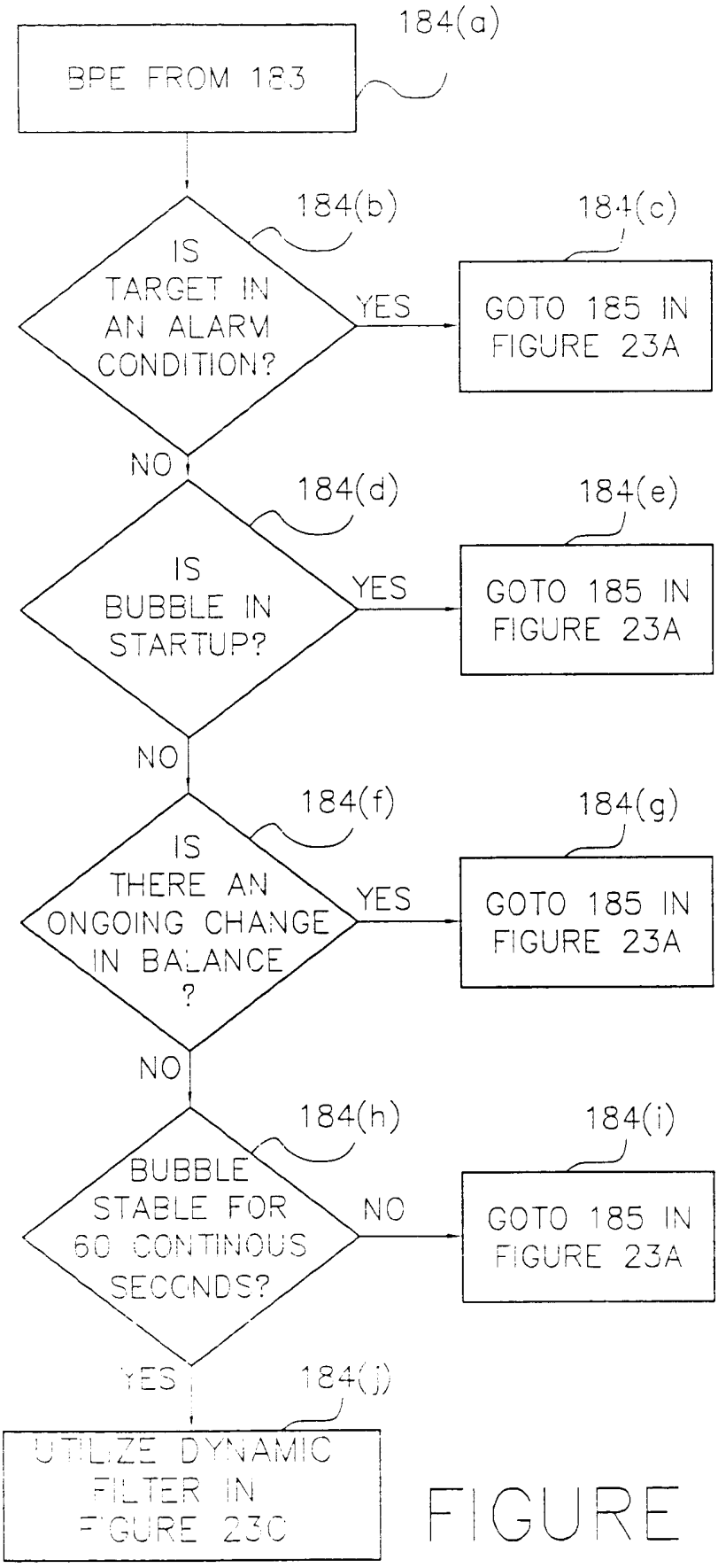

184(a)
BPE FROM 183
184(b)
IS TARGET IN AN ALARM CONDITION?
YES
184(c)
GOTO 185 IN FIGURE 23A
NO
184(d)
IS BUBBLE IN STARTUP?
YES
184(e)
GOTO 185 IN FIGURE 23A
NO
184(f)
IS THERE AN ONGOING CHANGE IN BALANCE ?
YES
184(g)
GOTO 185 IN FIGURE 23A
NO
184(h)
BUBBLE STABLE FOR 60 CONTINOUS SECONDS?
NO
184(i)
GOTO 185 IN FIGURE 23A
YES
184(j)
UTILIZE DYNAMIC FILTER IN FIGURE 23C

FIGURE 23B

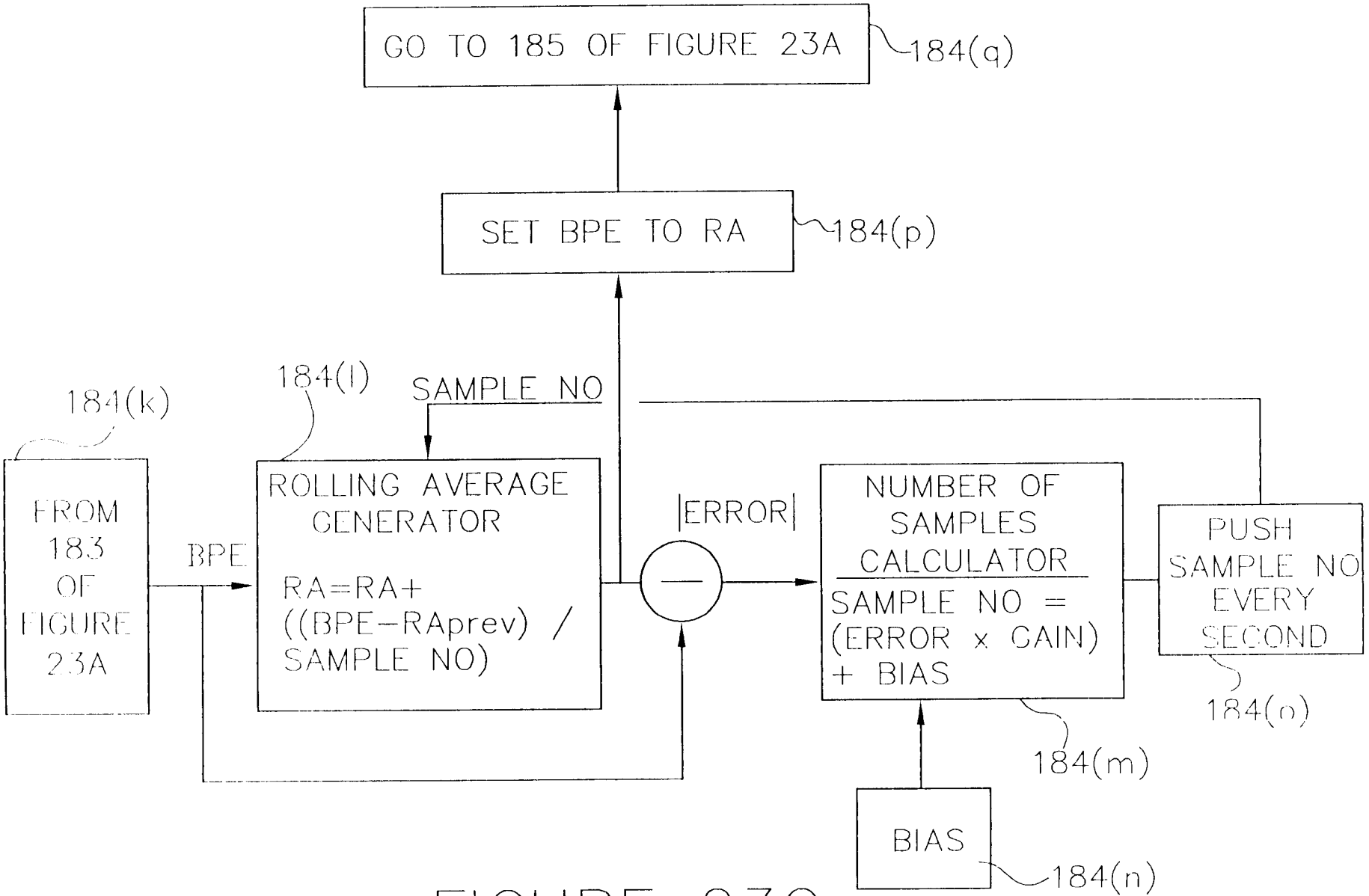

GO TO 185 OF FIGURE 23A
184(q)
SET BPE TO RA
184(p)
184(l)
SAMPLE NO
184(k)
FROM 183 OF FIGURE 23A
BPE
ROLLING AVERAGE GENERATOR
RA=RA+ ((BPE−RAprev) / SAMPLE NO)
|ERROR|
NUMBER OF SAMPLES CALCULATOR
SAMPLE NO = (ERROR x GAIN) + BIAS
184(m)
PUSH SAMPLE NO EVERY SECOND
184(o)
BIAS
184(n)

FIGURE 23C

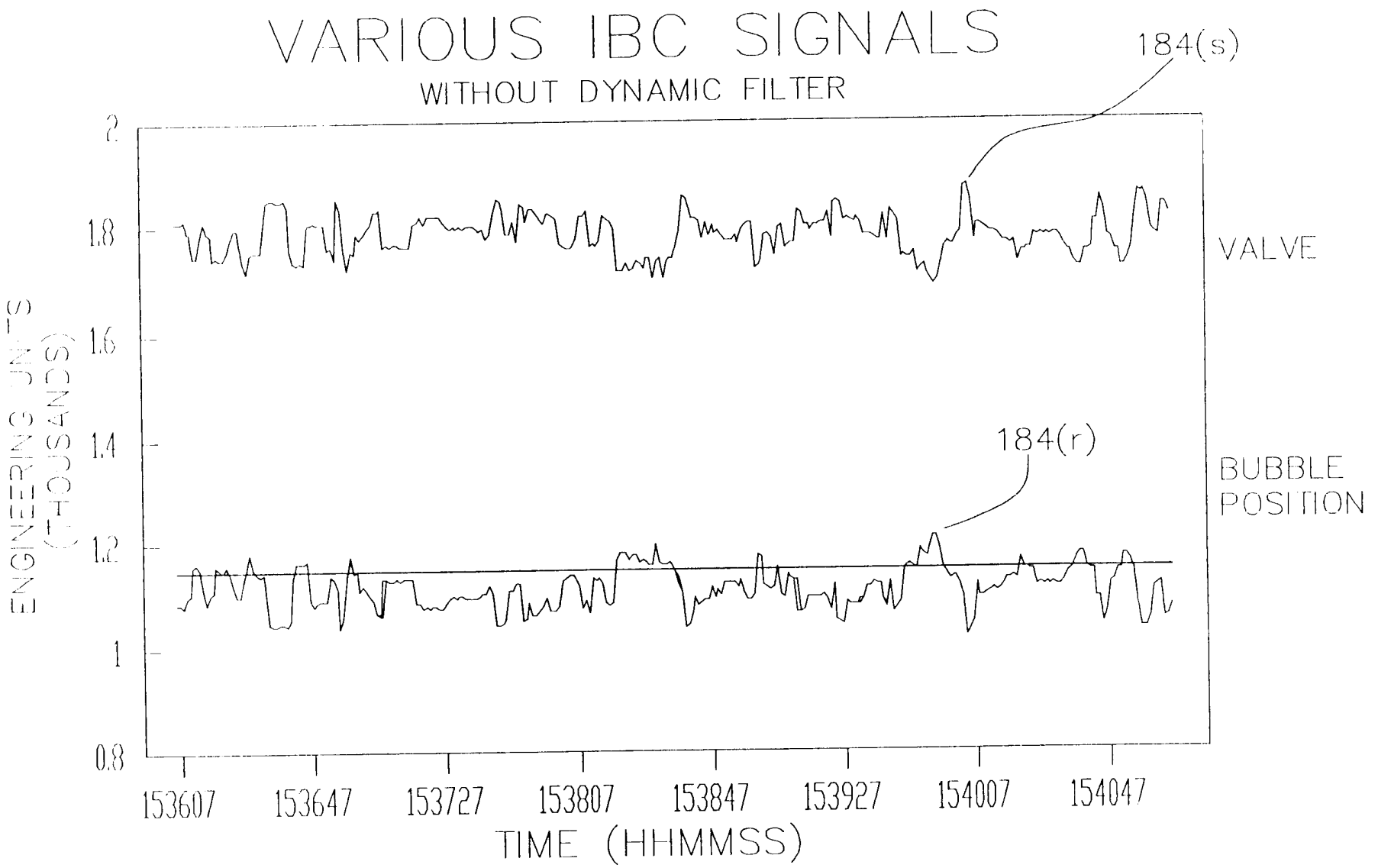

VARIOUS IBC SIGNALS
WITHOUT DYNAMIC FILTER
184(s)
184(r)
VALVE
BUBBLE POSITION
ENGINEERING UNITS (THOUSANDS)
2
1.8
1.6
1.4
1.2
1
0.8
153607
153647
153727
153807
153847
153927
154007
154047
TIME (HHMMSS)

FIGURE 23D

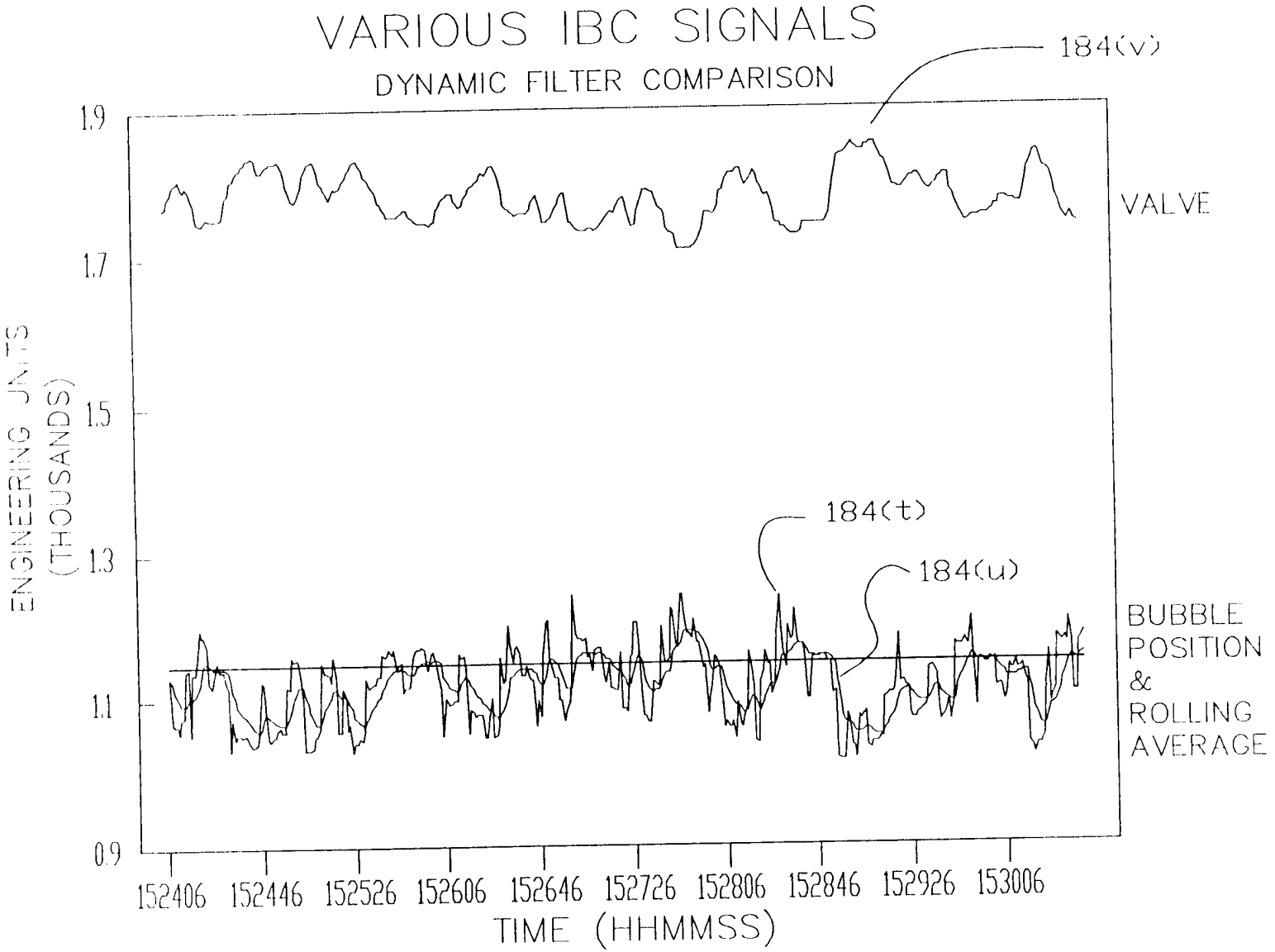

VARIOUS IBC SIGNALS
DYNAMIC FILTER COMPARISON
184(v)
VALVE
184(t)
184(u)
BUBBLE
POSITION
&
ROLLING
AVERAGE
ENGINEERING UNITS
(THOUSANDS)
1.9
1.7
1.5
1.3
1.1
0.9
152406
152446
152526
152606
152646
152726
152806
152846
152926
153006
TIME (HHMMSS)

FIGURE 23E

FREQUENCY DISTRIBUTION COMPARISON

DYNAMIC FILTER VS. BPE

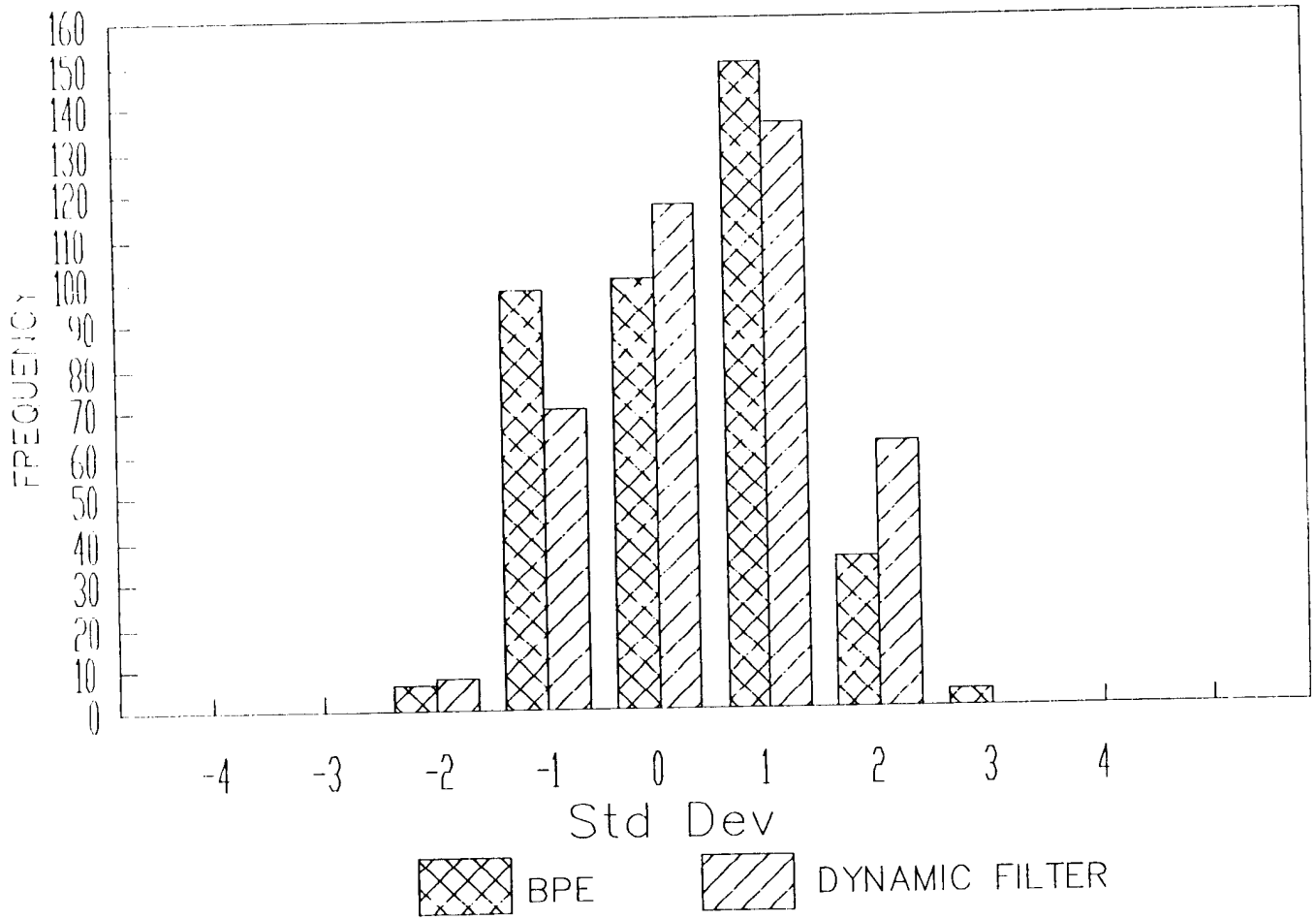


FIGURE 23F

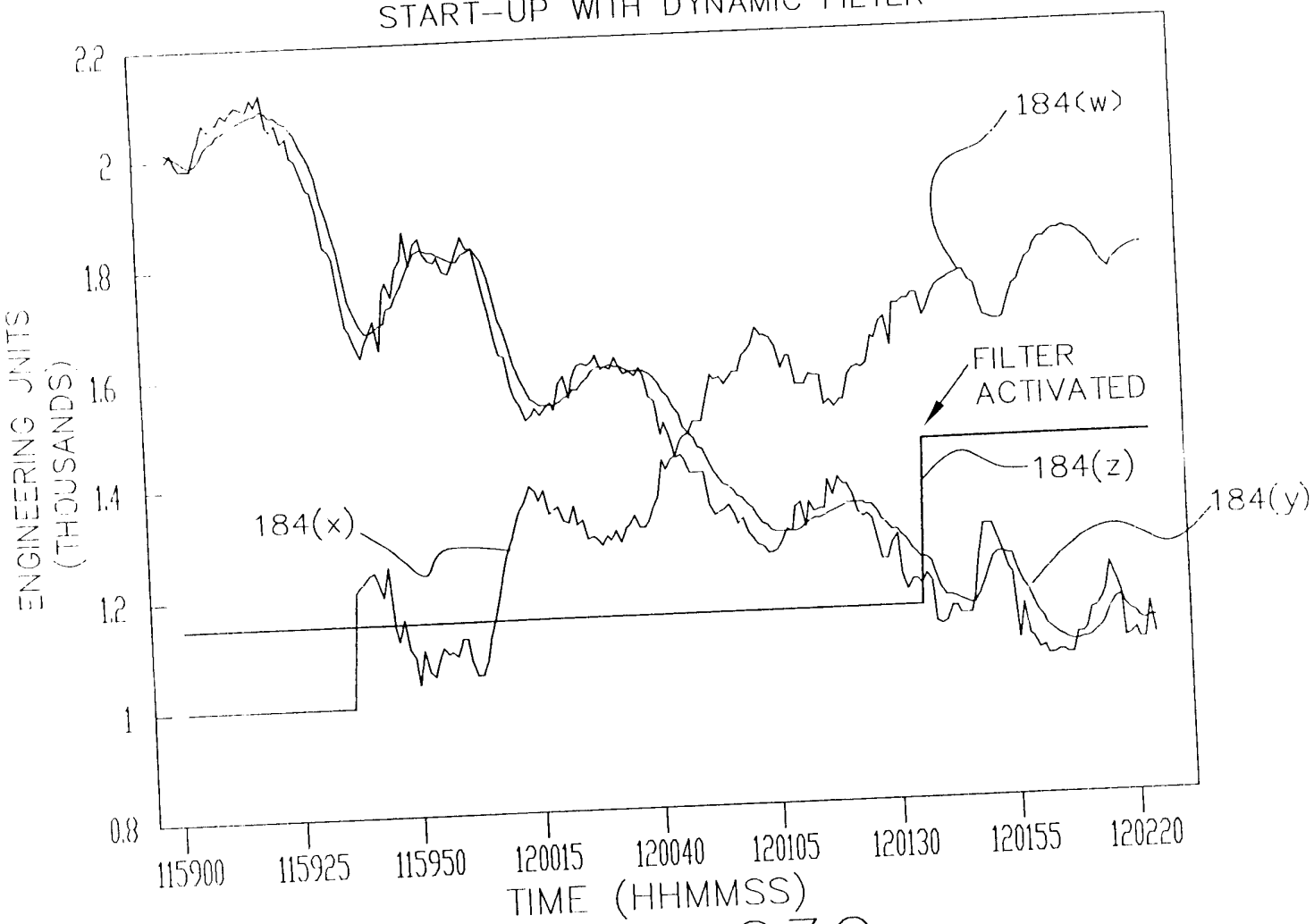

VARIOUS IBC SIGNALS
START-UP WITH DYNAMIC FILTER
ENGINEERING UNITS
(THOUSANDS)
2.2
2
1.8
1.6
1.4
1.2
1
0.8
184(w)
FILTER
ACTIVATED
184(z)
184(y)
184(x)
115900
115925
115950
120015
120040
120105
120130
120155
120220
TIME (HHMMSS)

FIGURE 23G

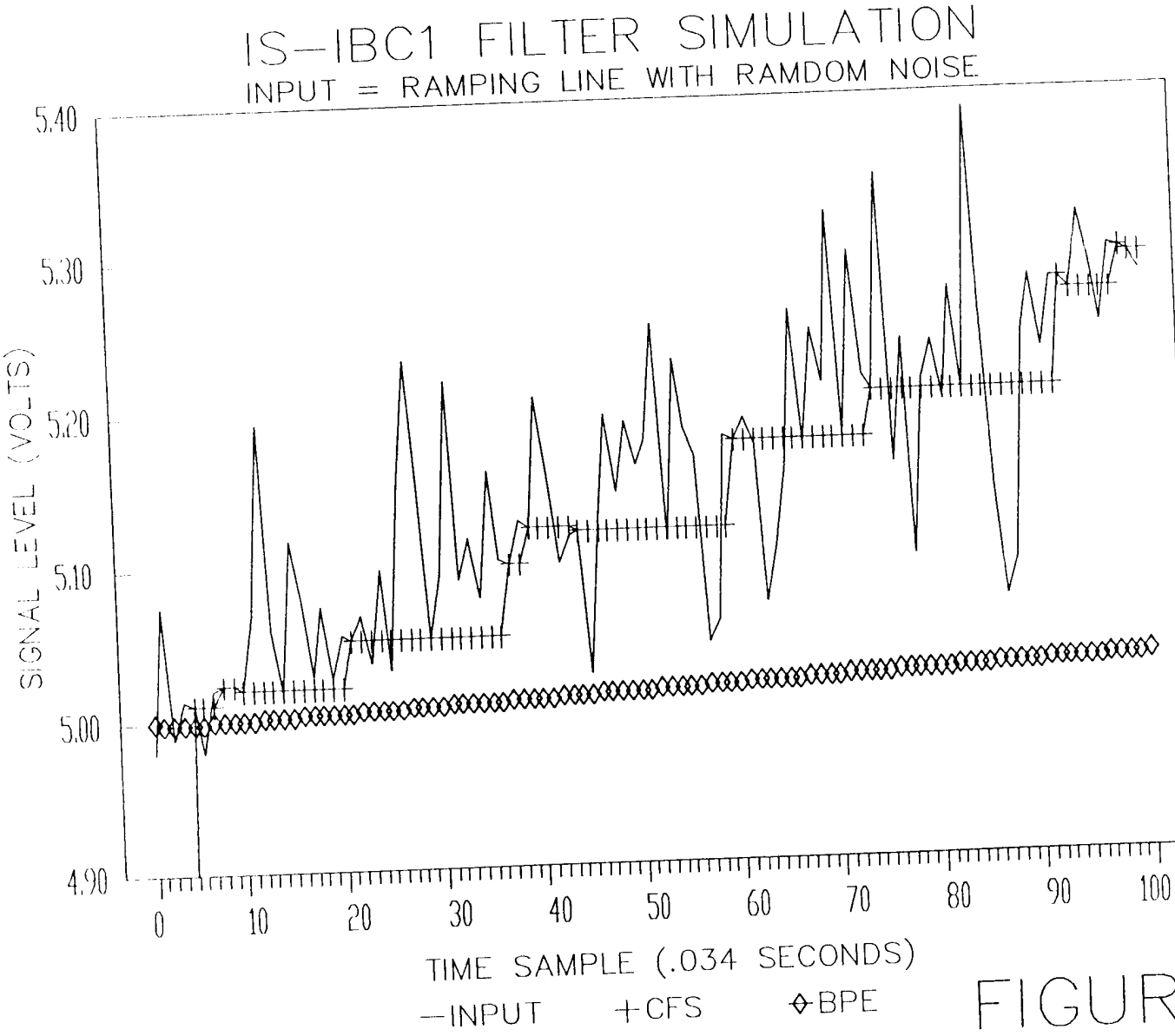
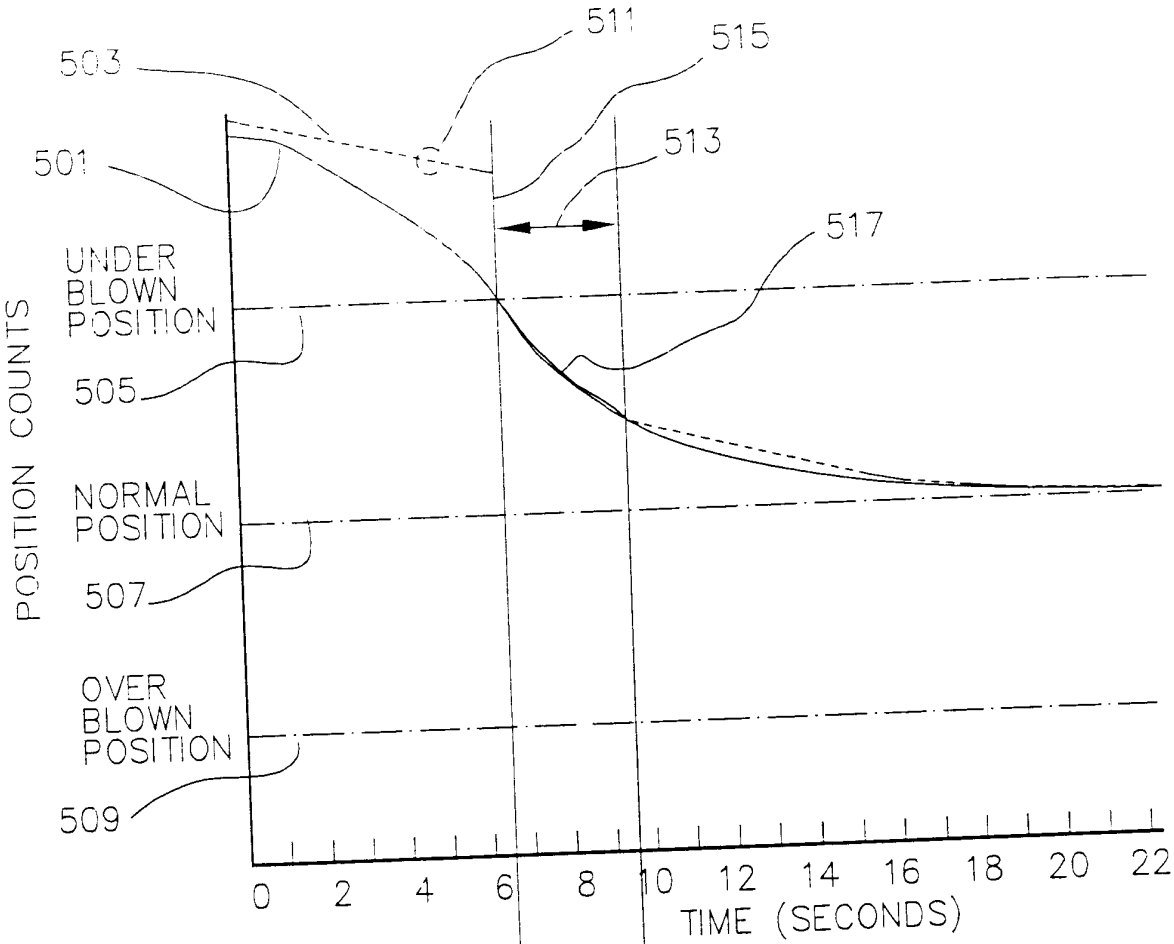

IS-IBC1 FILTER SIMULATION
INPUT = RAMPING LINE WITH RAMDOM NOISE
SIGNAL LEVEL (VOLTS)
5.40
5.30
5.20
5.10
5.00
4.90
0
10
20
30
40
50
60
70
80
90
100
TIME SAMPLE (.034 SECONDS)
-INPUT
+CFS
◇BPE

FIGURE 24

FIGURE 25A



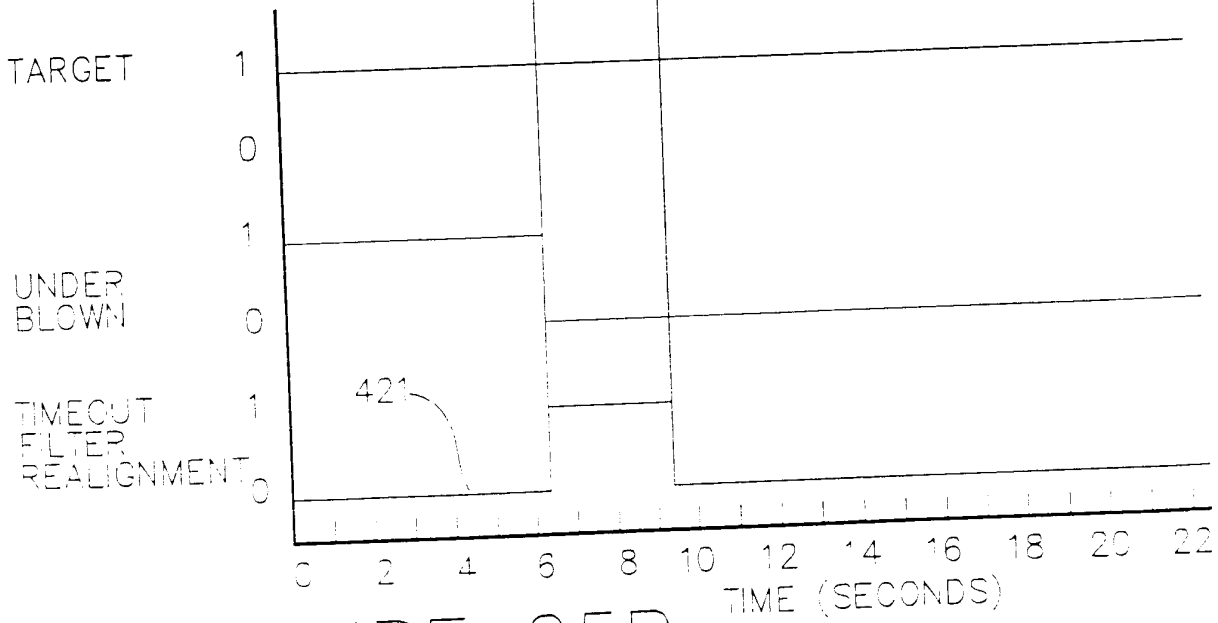
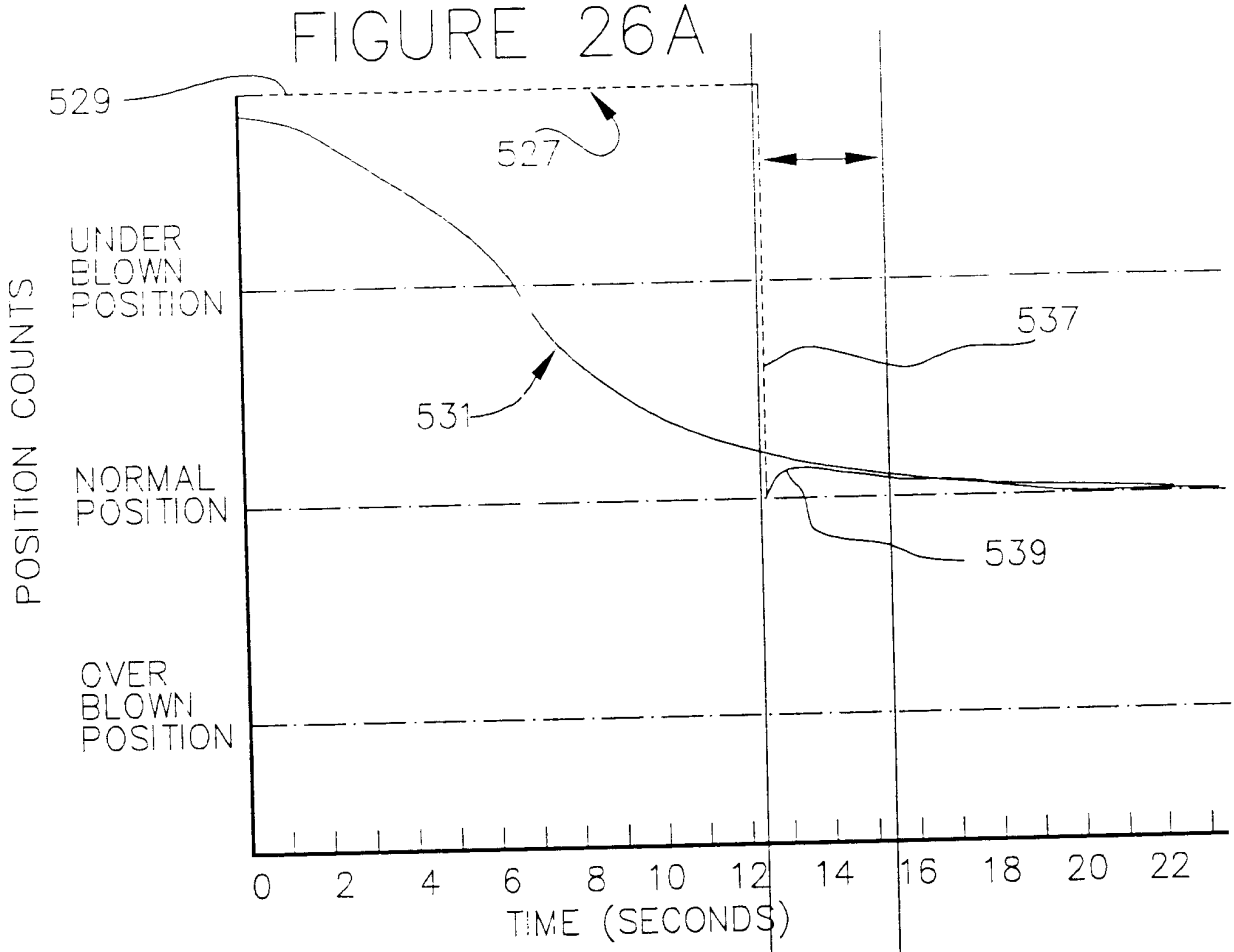


FIGURE 25B

FIGURE 26A



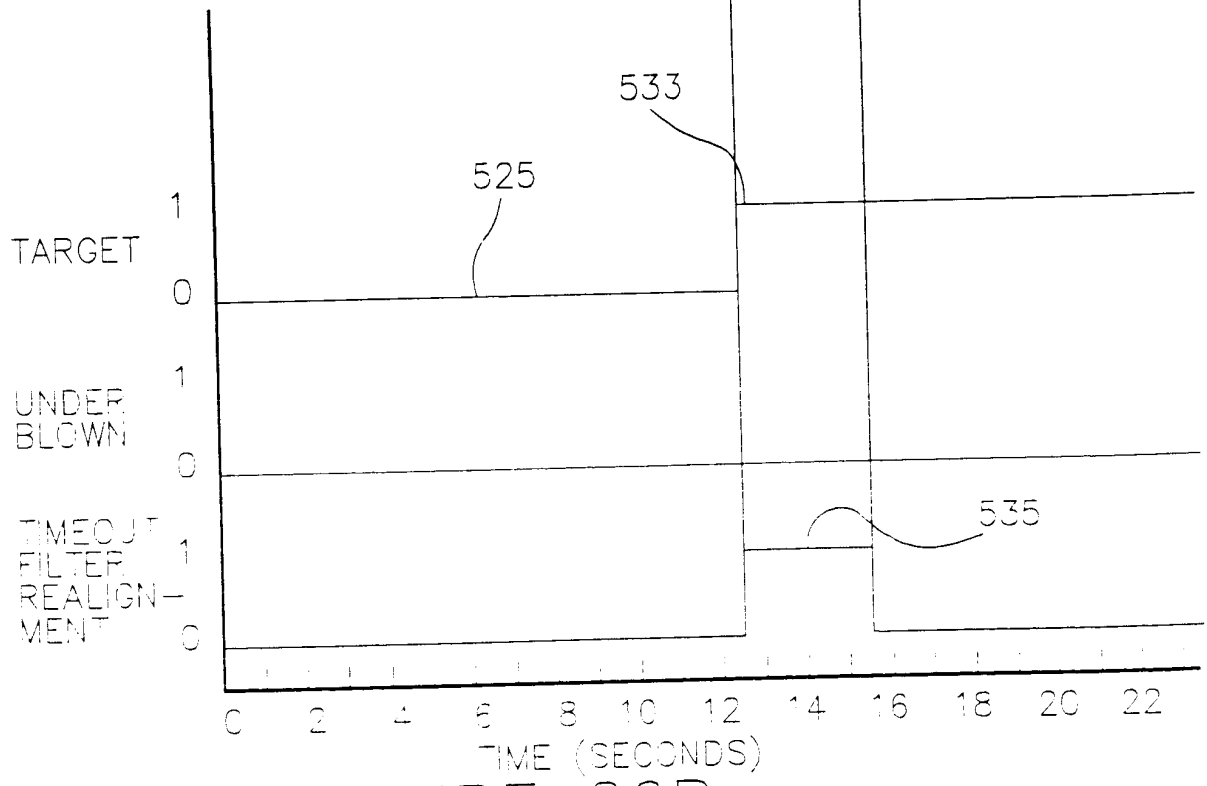
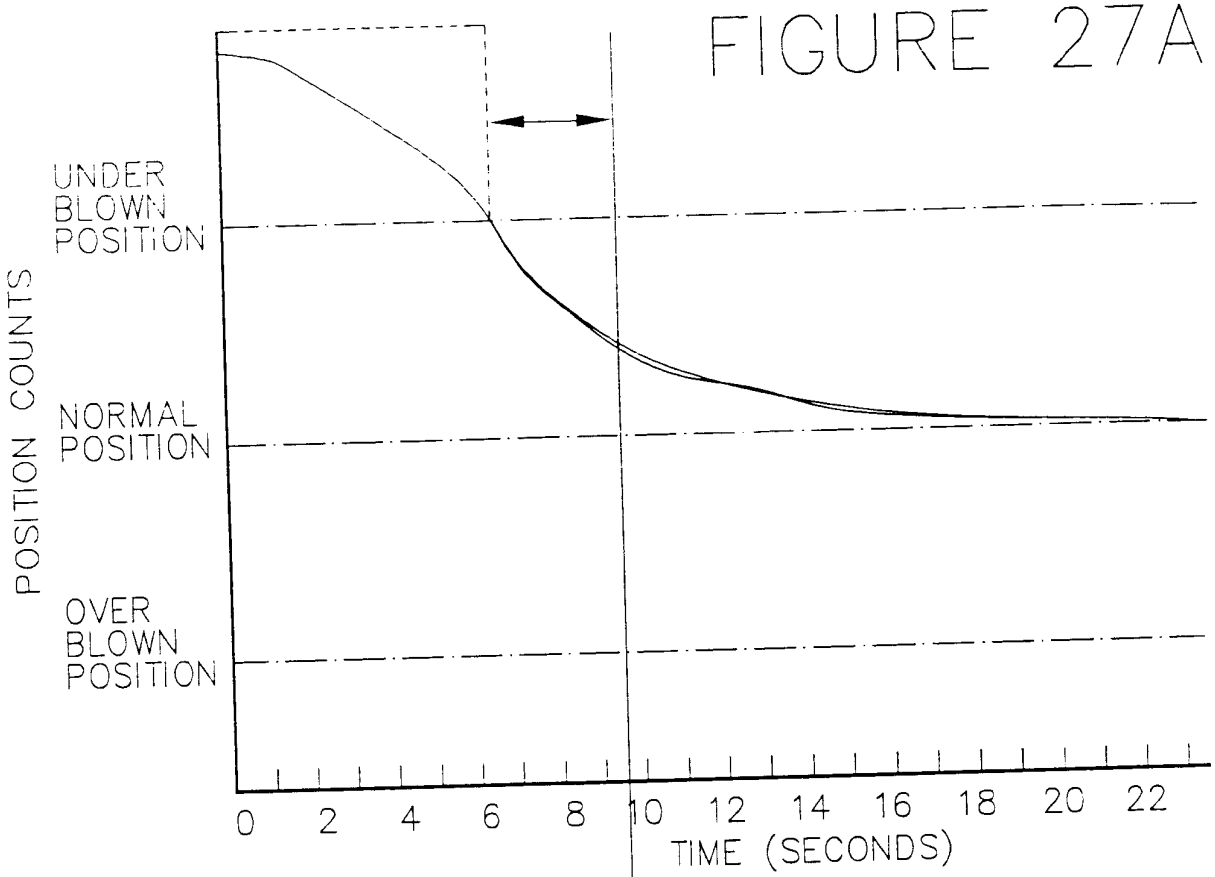


FIGURE 26B

FIGURE 27A



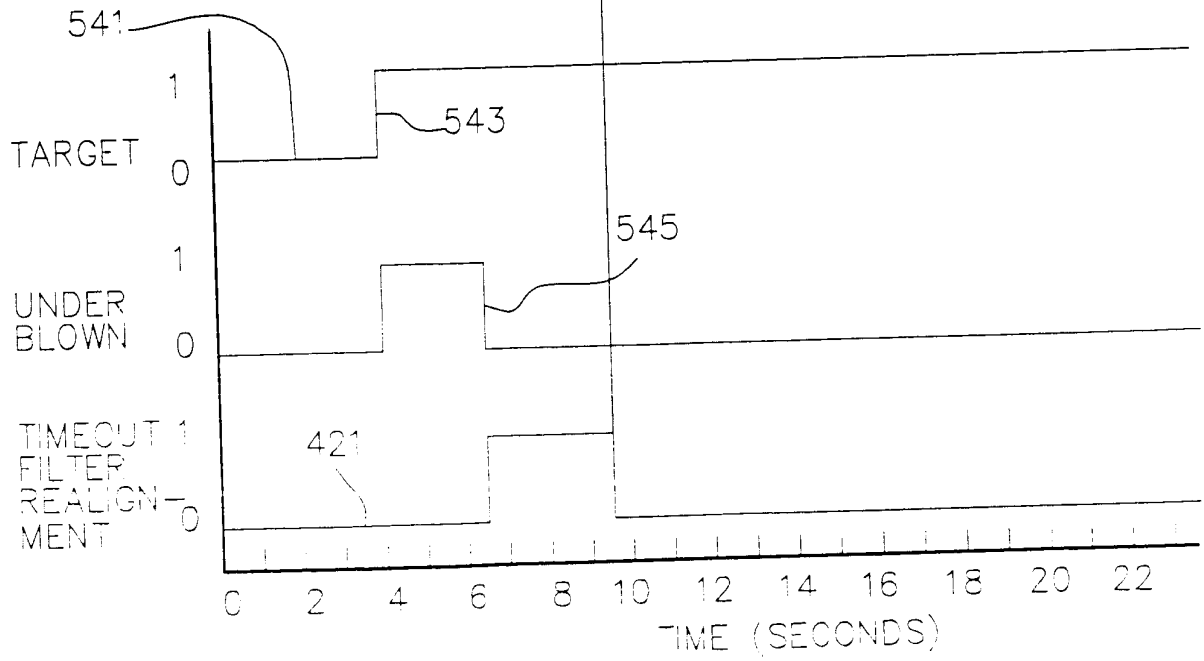


FIGURE 27B

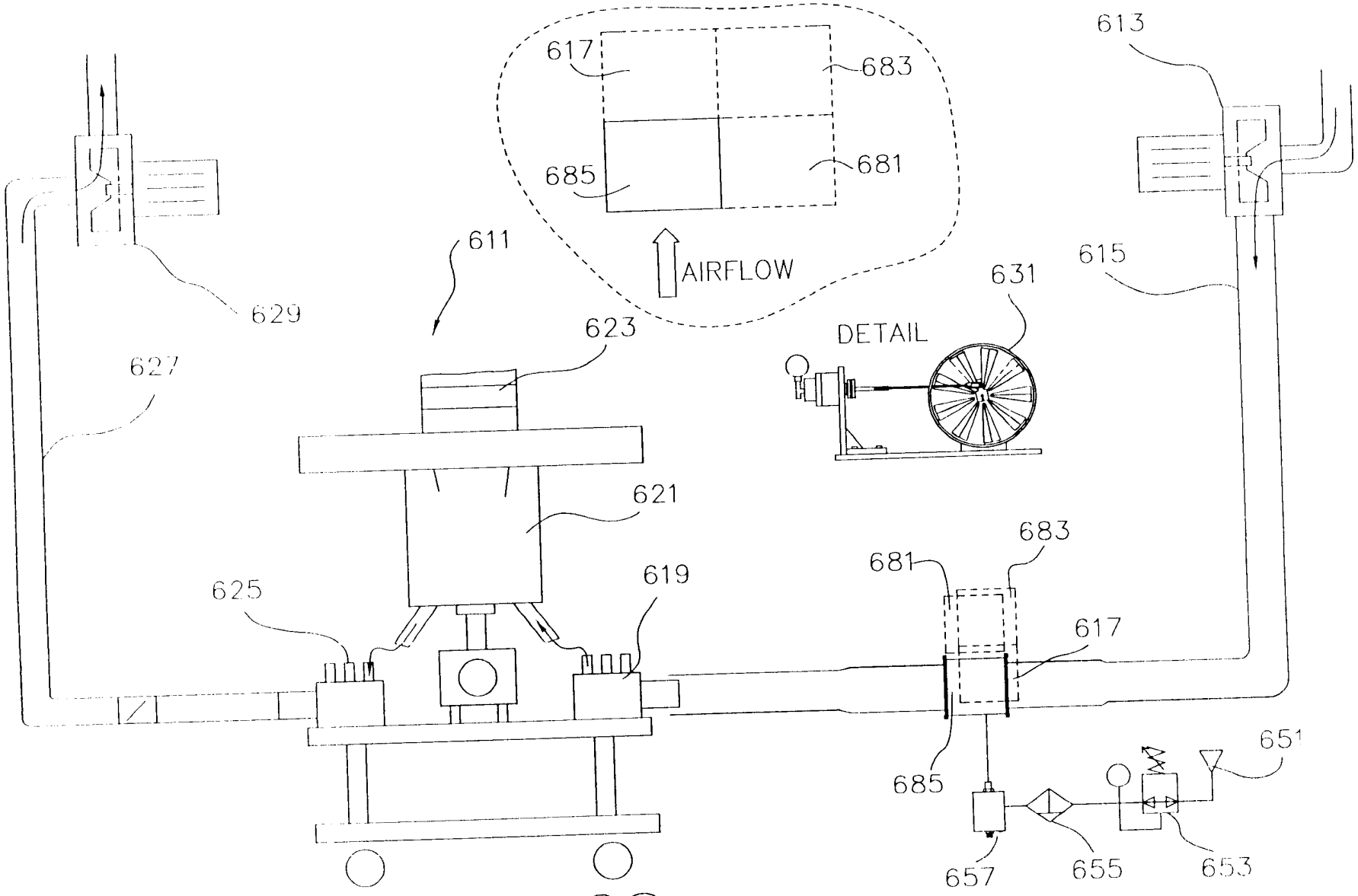

617
683
685
681
AIRFLOW
613
611
629
615
631
DETAIL
623
627
621
683
681
625
619
617
685
651
657
655
653

FIGURE 28

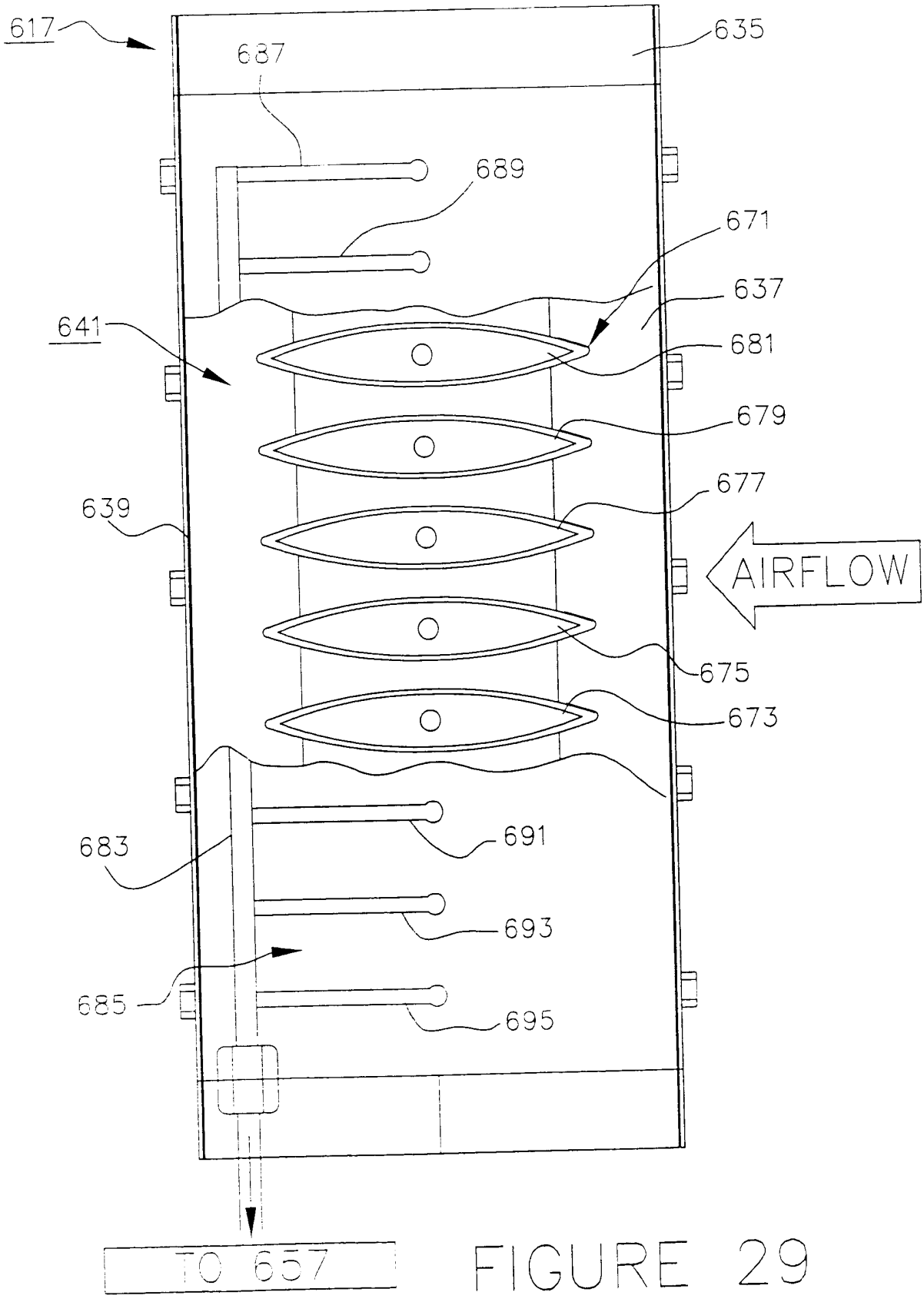

617
687
635
689
671
637
641
681
679
677
639
AIRFLOW
675
673
691
683
693
685
695
TO 657

FIGURE 29

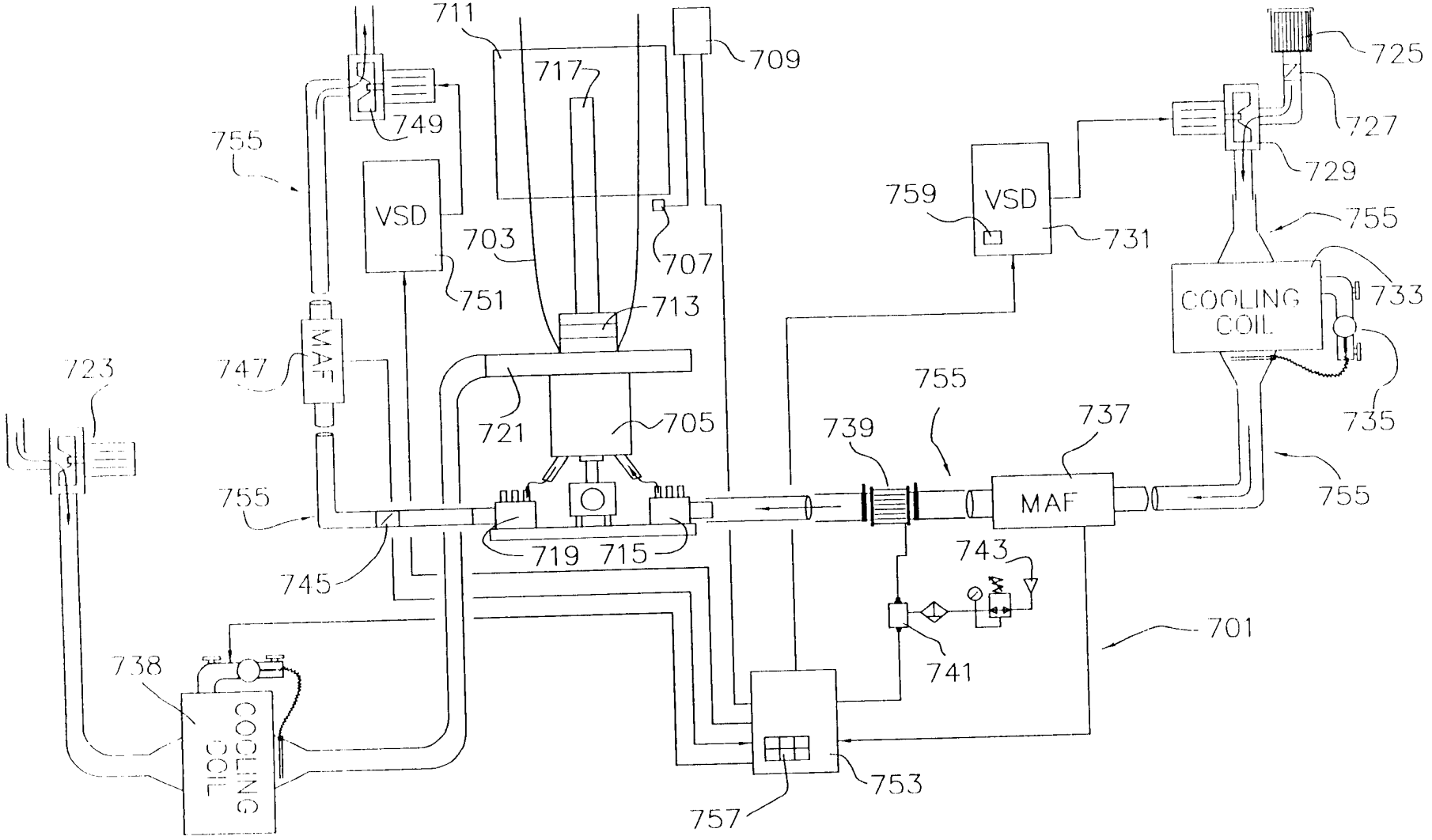

711
709
717
725
749
727
755
VSD
729
759
VSD
731
703
707
755
751
713
733
COOLING COIL
MAF
747
723
721
705
739
755
737
735
755
MAF
755
719
715
743
745
701
738
741
COOLING COIL
753
757

FIGURE 30

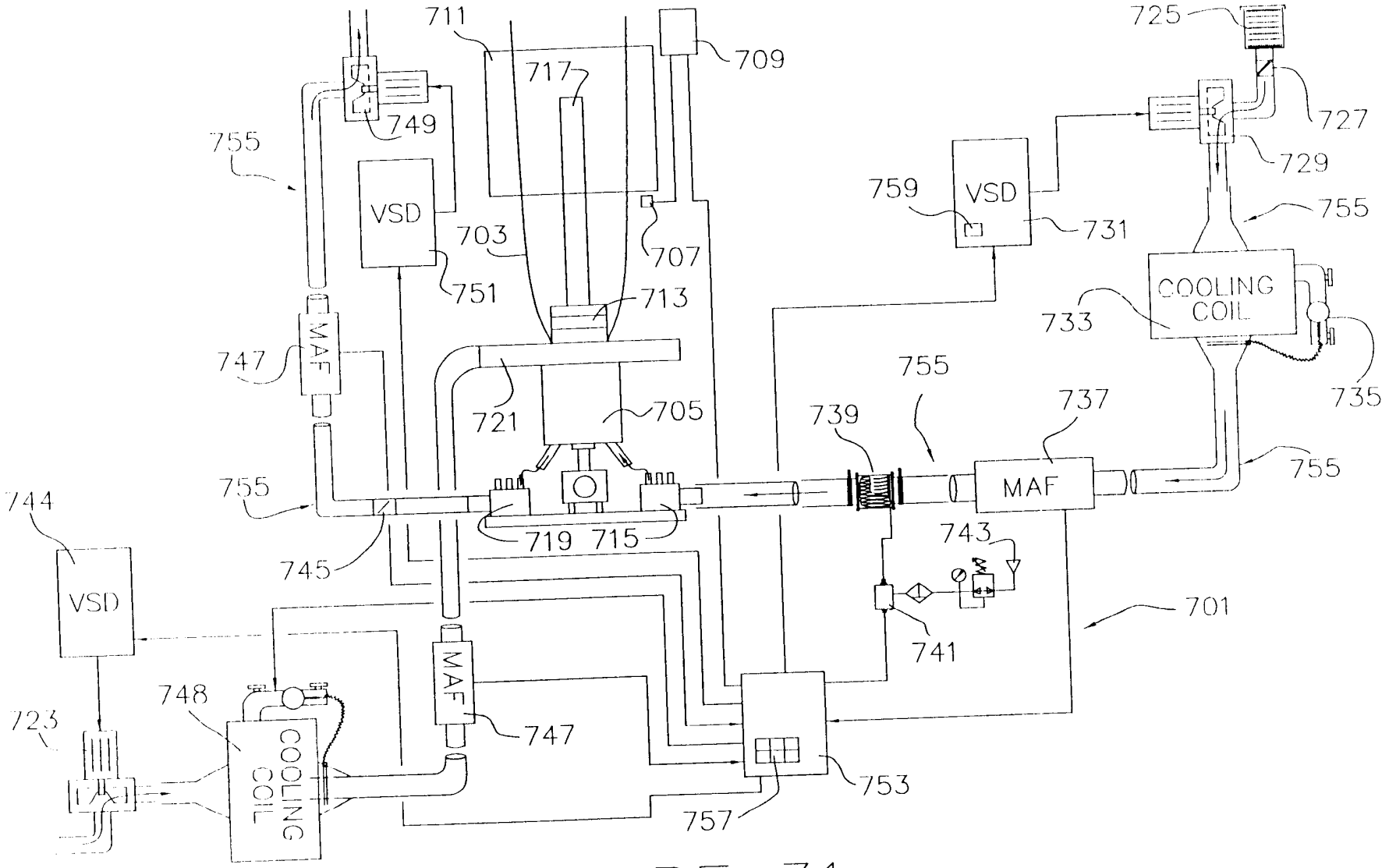

711
709
717
725
727
749
755
VSD
703
707
751
713
729
759
VSD
731
755
MAF
747
721
705
733
COOLING COIL
735
755
739
737
755
755
MAF
744
719
715
743
745
VSD
701
741
MAF
748
723
747
COOLING COIL
753
757

FIGURE 31

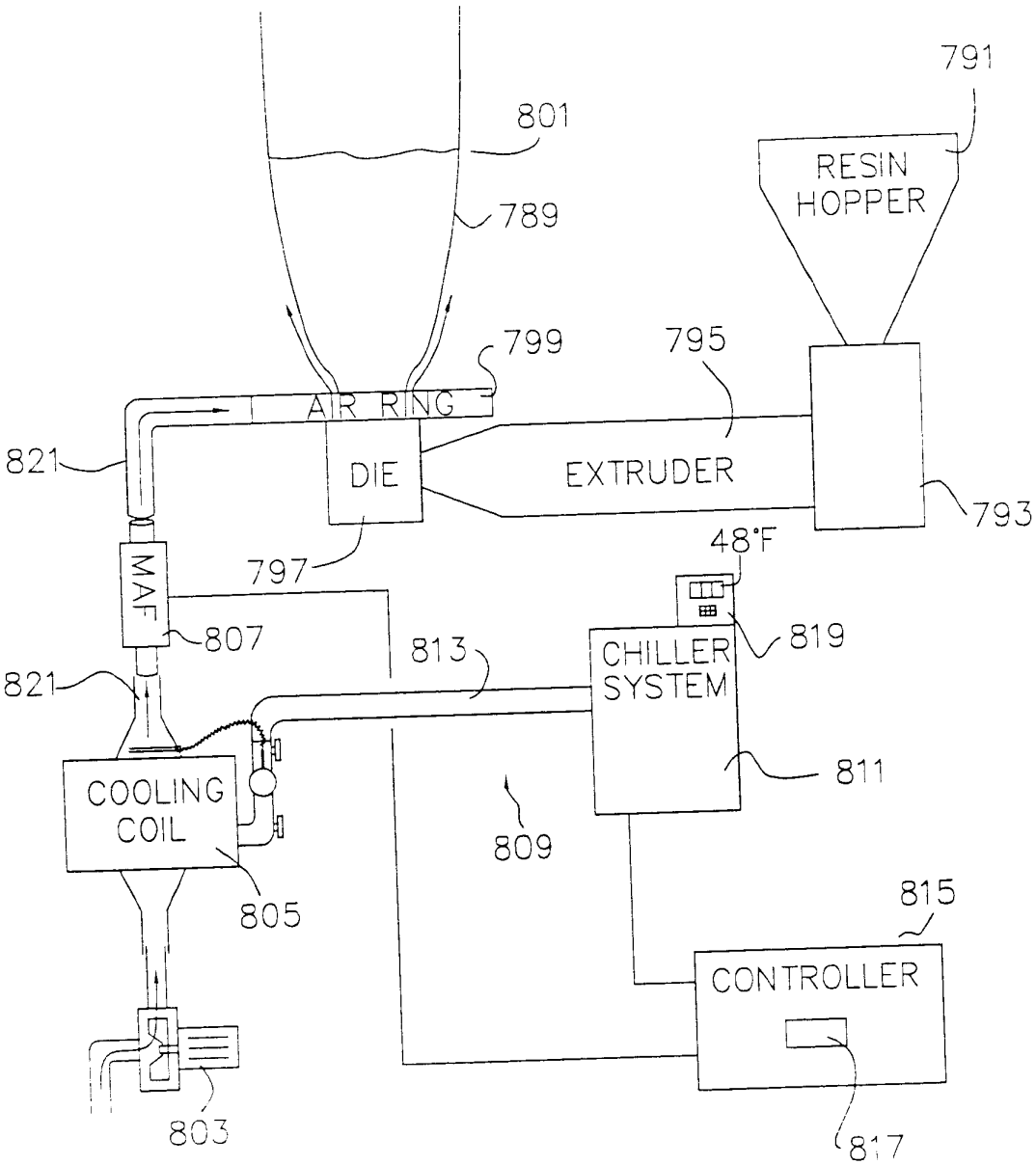

791
801
RESIN HOPPER
789
799
795
AIR RING
821
DIE
EXTRUDER
793
797
48°F
MAF
807
813
819
821
CHILLER SYSTEM
811
COOLING COIL
809
805
815
CONTROLLER
803
817

FIGURE 32

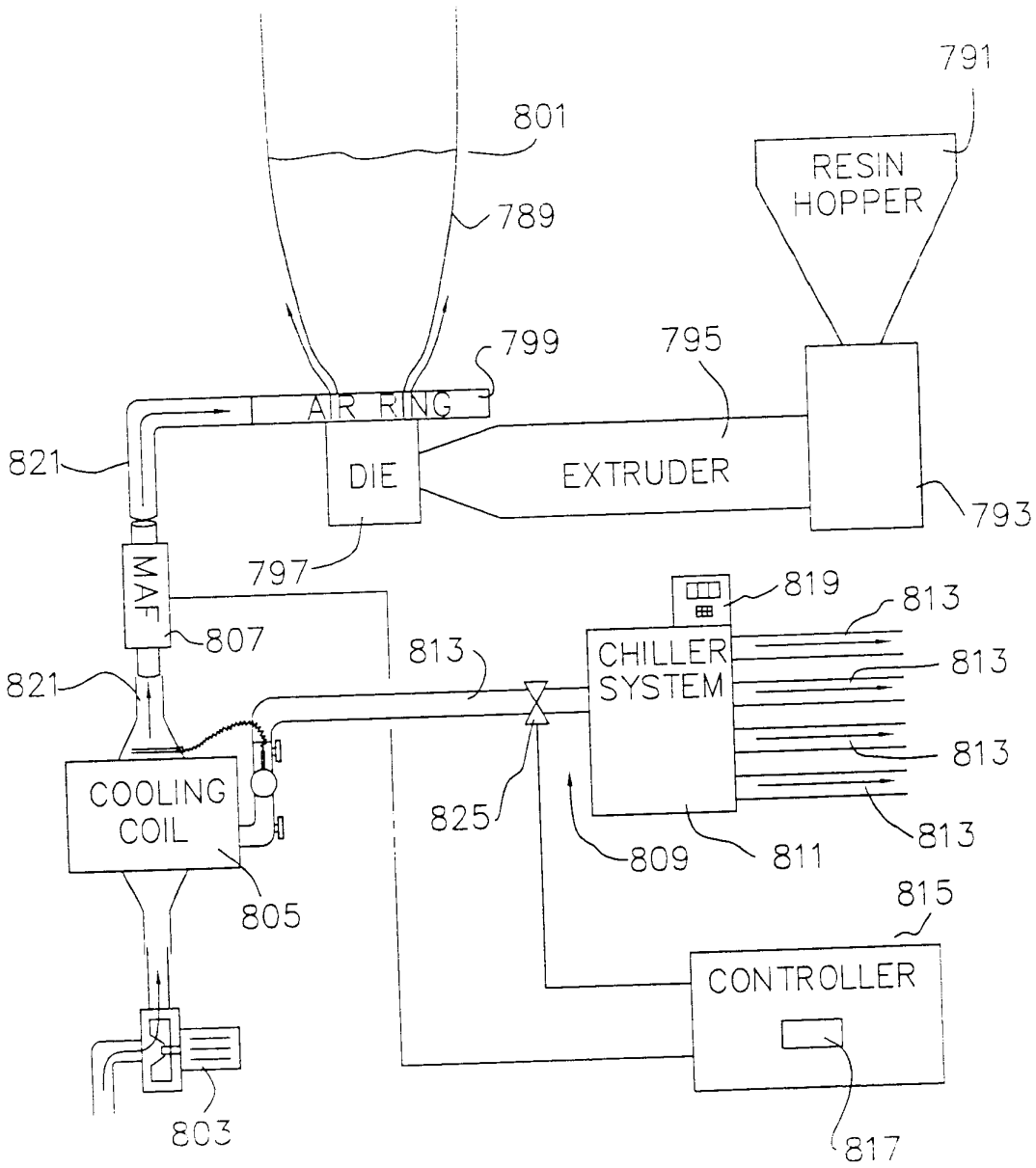

791
801
RESIN HOPPER
789
799
795
AIR RING
821
DIE
EXTRUDER
793
797
MAF
807
819
813
813
CHILLER SYSTEM
821
813
813
COOLING COIL
825
809
811
813
805
815
CONTROLLER
803
817

FIGURE 33

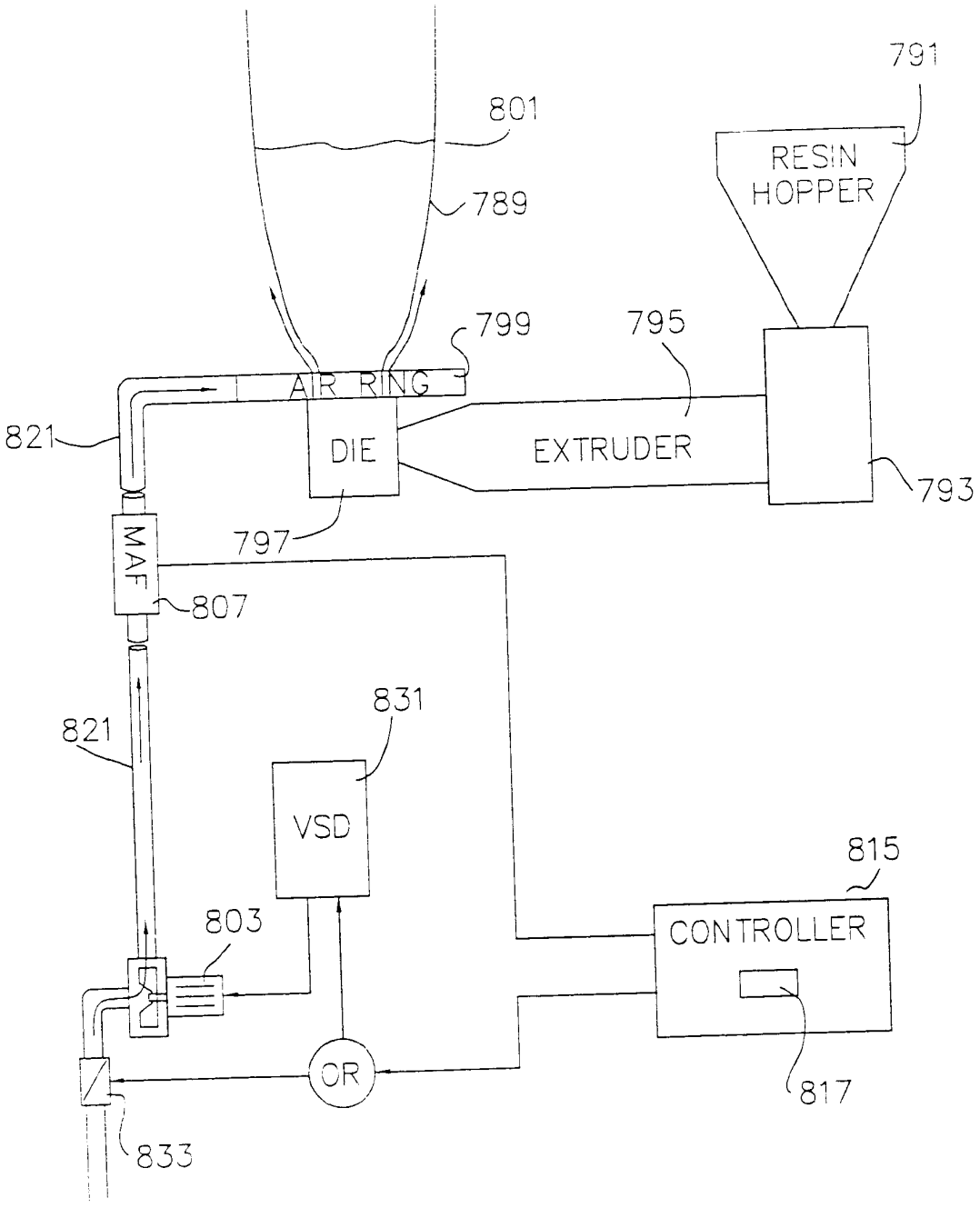

791
801
RESIN
HOPPER
789
799
795
AIR RING
821
DIE
EXTRUDER
793
797
MAF
807
831
821
VSD
815
803
CONTROLLER
OR
817
833

FIGURE 34

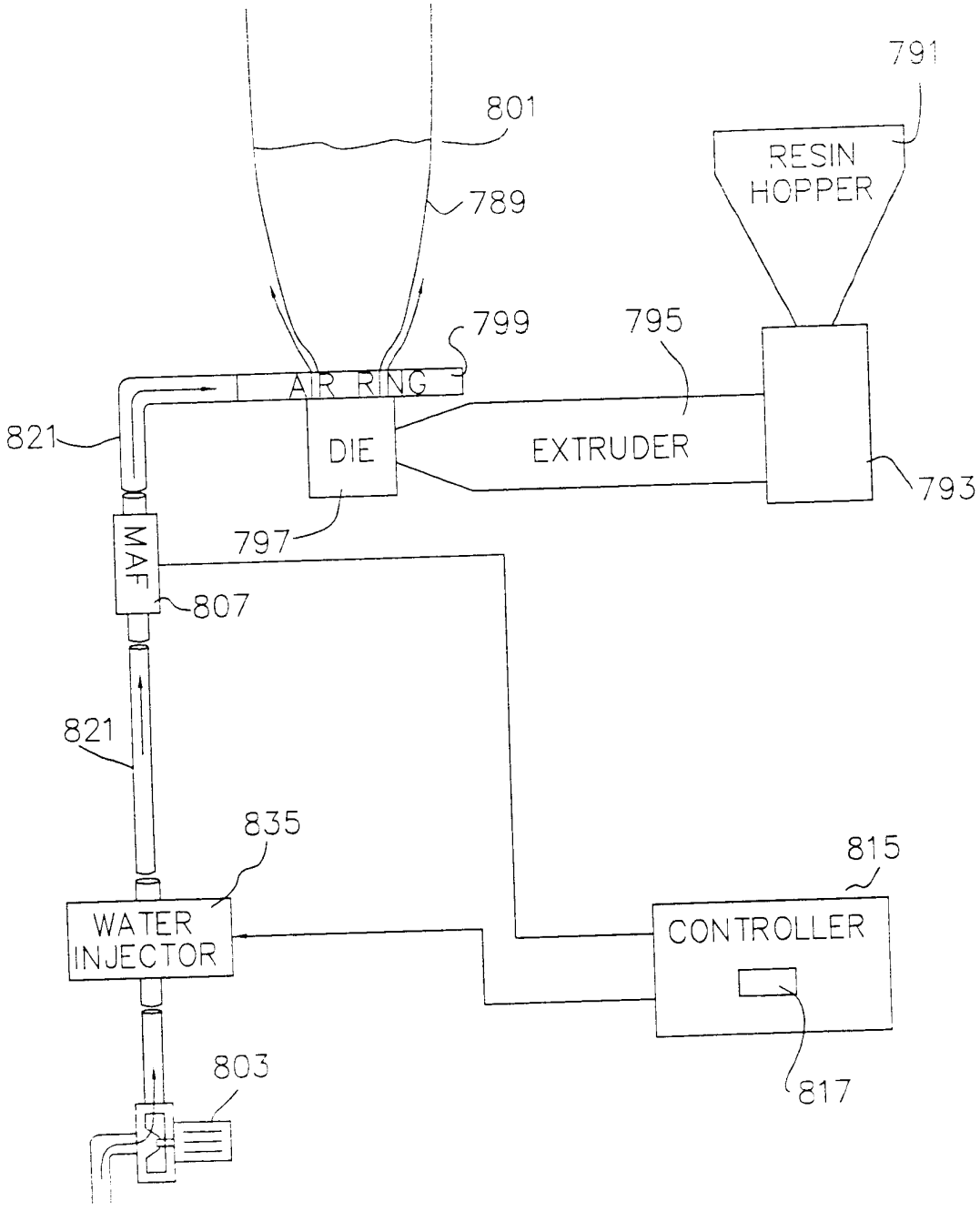

791
801
RESIN
HOPPER
789
799
795
AIR RING
821
DIE
EXTRUDER
793
797
MAF
807
821
835
815
WATER
INJECTOR
CONTROLLER
803
817

FIGURE 35

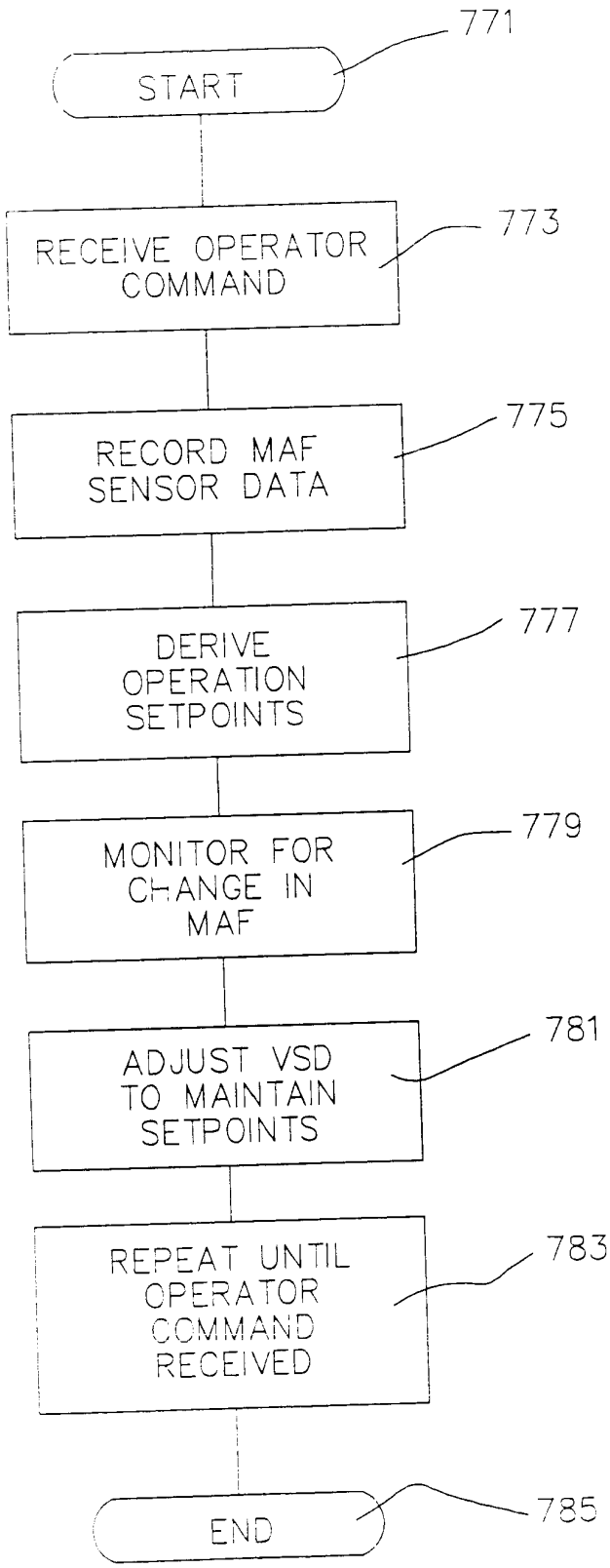

771
START
RECEIVE OPERATOR COMMAND
773
RECORD MAF SENSOR DATA
775
DERIVE OPERATION SETPOINTS
777
MONITOR FOR CHANGE IN MAF
779
ADJUST VSD TO MAINTAIN SETPOINTS
781
REPEAT UNTIL OPERATOR COMMAND RECEIVED
783
END
785

FIGURE 36

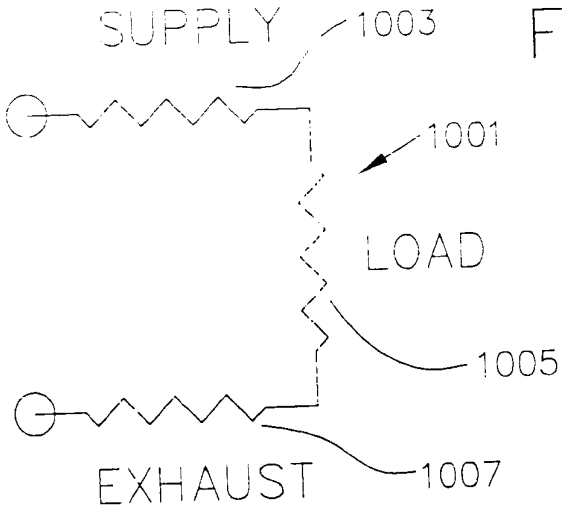


FIGURE 37A
(PRIOR ART)

FIGURE 37B
(PRIOR ART)

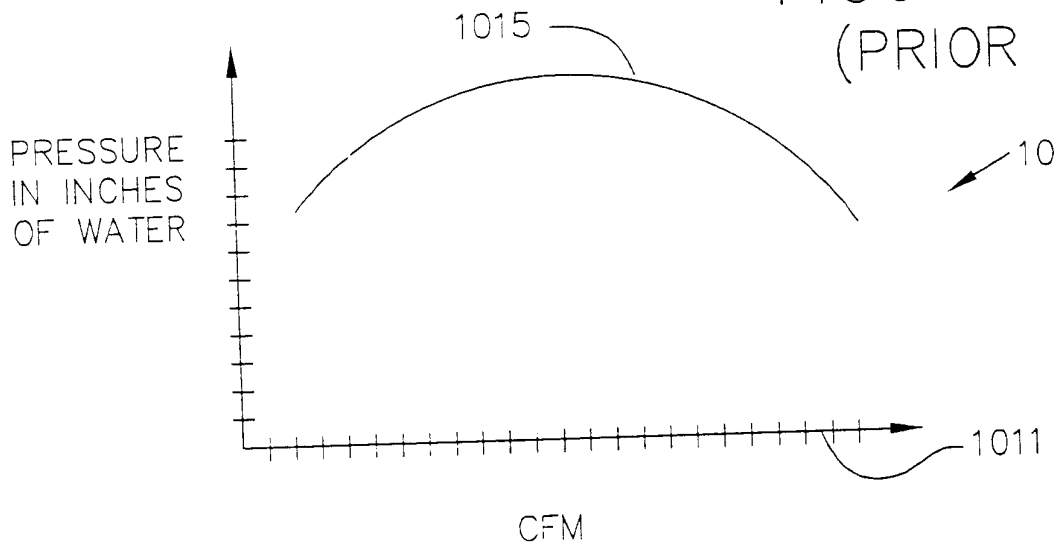
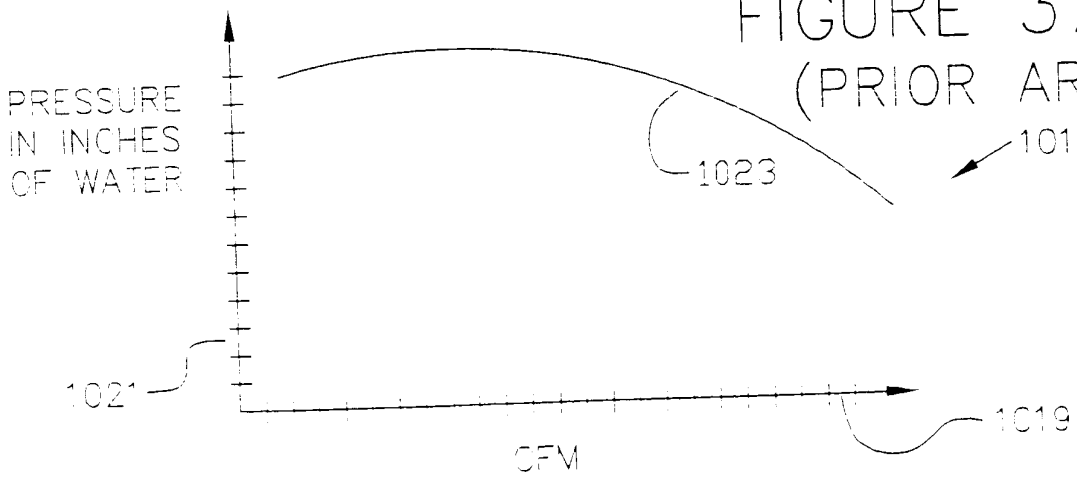


FIGURE 37C
(PRIOR ART)



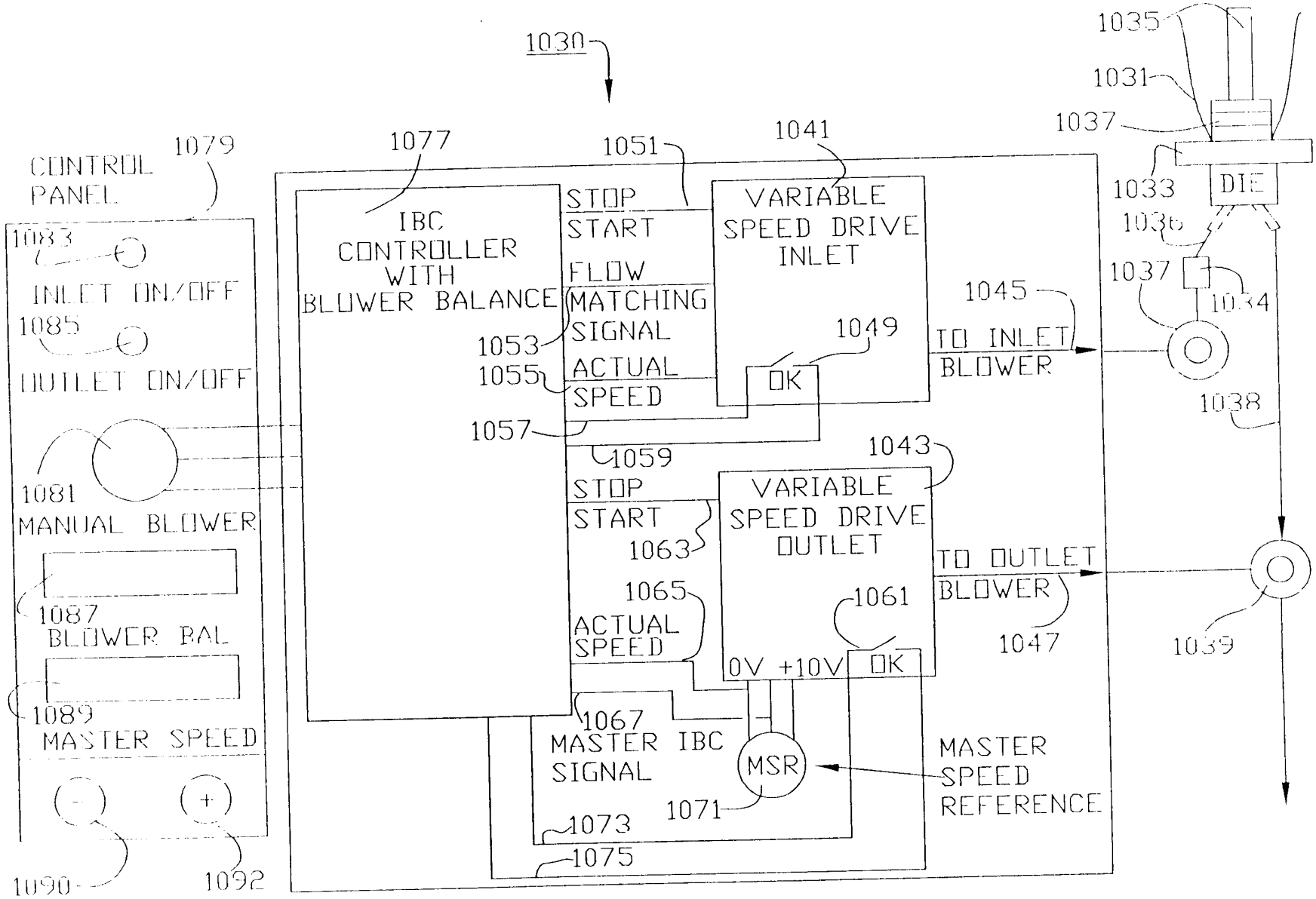

1030
1035
1031
1037
1033
DIE
1036
1037
1034
1038
1039
1041
1051
1077
1079
CONTROL PANEL
1083
INLET ON/OFF
1085
OUTLET ON/OFF
1081
MANUAL BLOWER
1087
BLOWER BAL
1089
MASTER SPEED
1090
1092
IBC CONTROLLER WITH BLOWER BALANCE
STOP
START
FLOW
MATCHING
SIGNAL
ACTUAL
SPEED
1053
1055
1057
1059
VARIABLE SPEED DRIVE INLET
1049
OK
1045
TO INLET BLOWER
1043
VARIABLE SPEED DRIVE OUTLET
1063
1065
ACTUAL SPEED
1061
0V +10V
OK
TO OUTLET BLOWER
1047
1067
MASTER IBC SIGNAL
MSR
1071
MASTER SPEED REFERENCE
1073
1075

FIGURE 37D

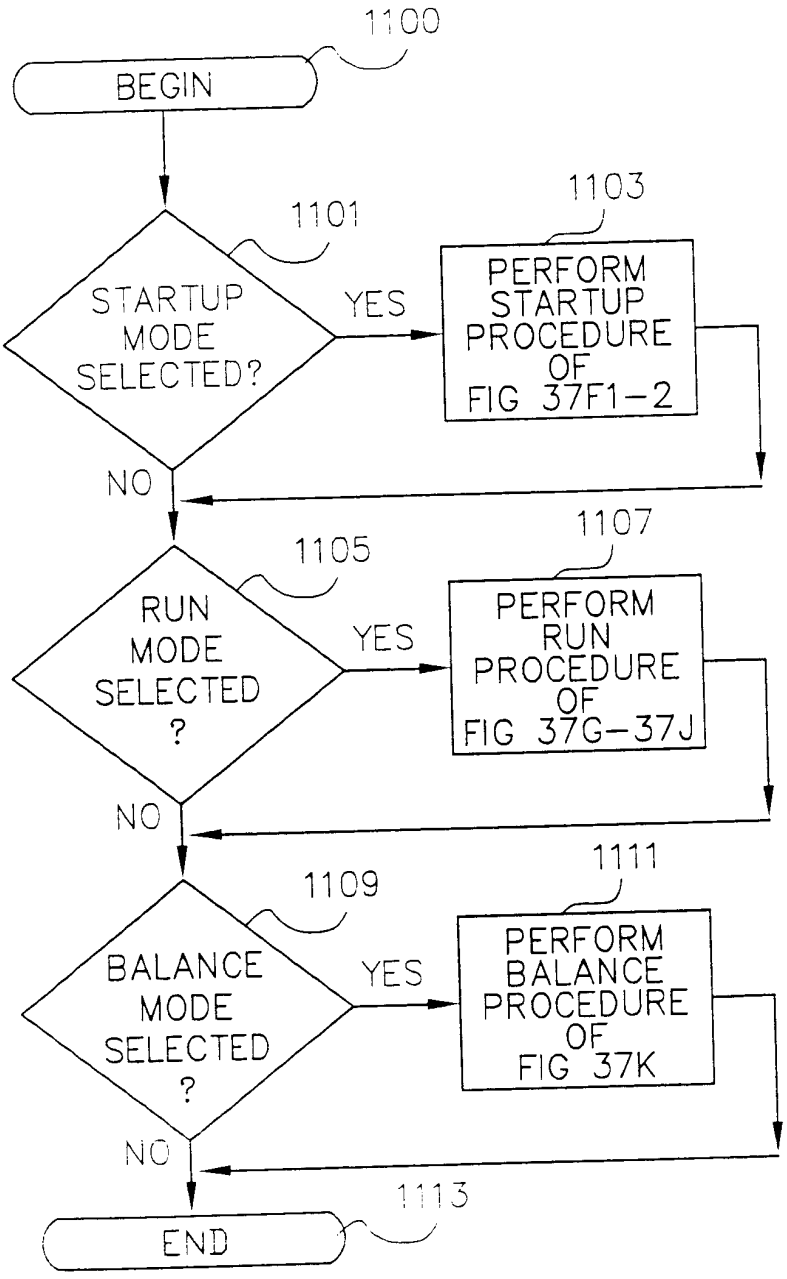

1100
BEGIN
1101
STARTUP MODE SELECTED?
YES
1103
PERFORM STARTUP PROCEDURE OF FIG 37F1-2
NO
1105
RUN MODE SELECTED ?
YES
1107
PERFORM RUN PROCEDURE OF FIG 37G-37J
NO
1109
BALANCE MODE SELECTED ?
YES
1111
PERFORM BALANCE PROCEDURE OF FIG 37K
NO
1113
END

FIGURE 37E

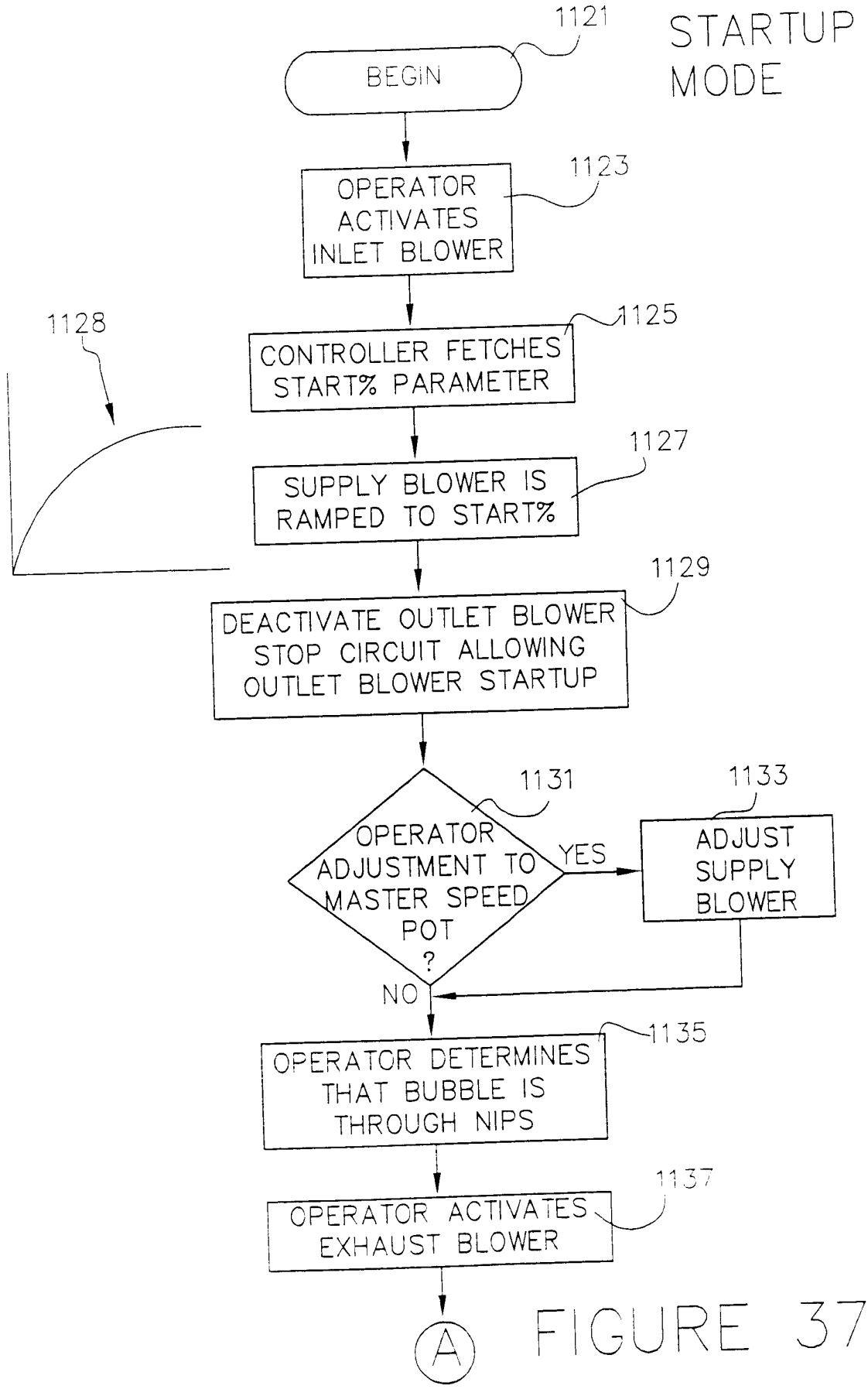

STARTUP MODE
1121
BEGIN
1123
OPERATOR ACTIVATES INLET BLOWER
1125
CONTROLLER FETCHES START% PARAMETER
1128
1127
SUPPLY BLOWER IS RAMPED TO START%
1129
DEACTIVATE OUTLET BLOWER STOP CIRCUIT ALLOWING OUTLET BLOWER STARTUP
1131
OPERATOR ADJUSTMENT TO MASTER SPEED POT ?
YES
1133
ADJUST SUPPLY BLOWER
NO
1135
OPERATOR DETERMINES THAT BUBBLE IS THROUGH NIPS
1137
OPERATOR ACTIVATES EXHAUST BLOWER
A

FIGURE 37F1

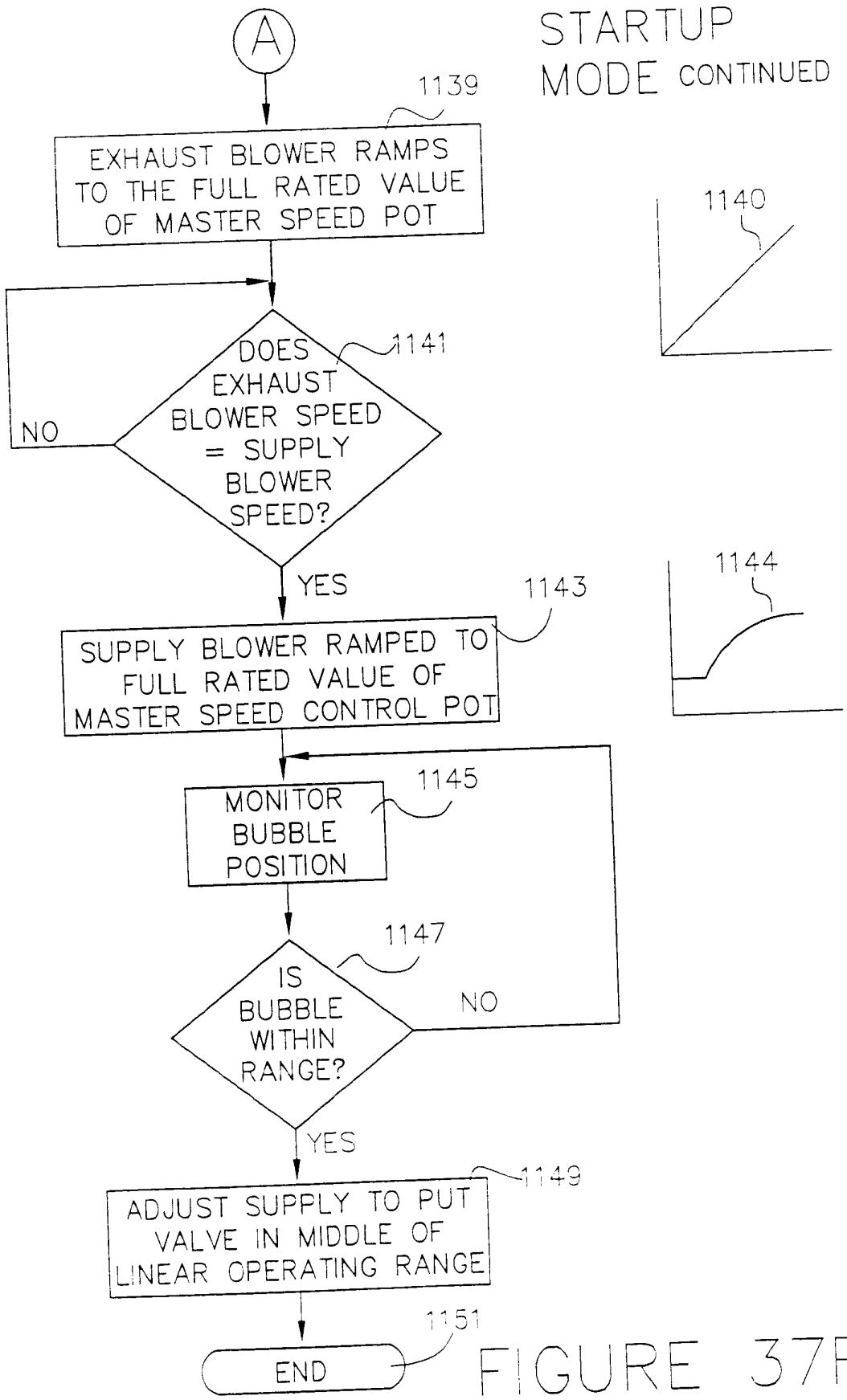

A
STARTUP MODE CONTINUED
1139
EXHAUST BLOWER RAMPS TO THE FULL RATED VALUE OF MASTER SPEED POT
1140
1141
DOES EXHAUST BLOWER SPEED = SUPPLY BLOWER SPEED?
NO
YES
1143
SUPPLY BLOWER RAMPED TO FULL RATED VALUE OF MASTER SPEED CONTROL POT
1144
1145
MONITOR BUBBLE POSITION
1147
IS BUBBLE WITHIN RANGE?
NO
YES
1149
ADJUST SUPPLY TO PUT VALVE IN MIDDLE OF LINEAR OPERATING RANGE
1151
END

FIGURE 37F2

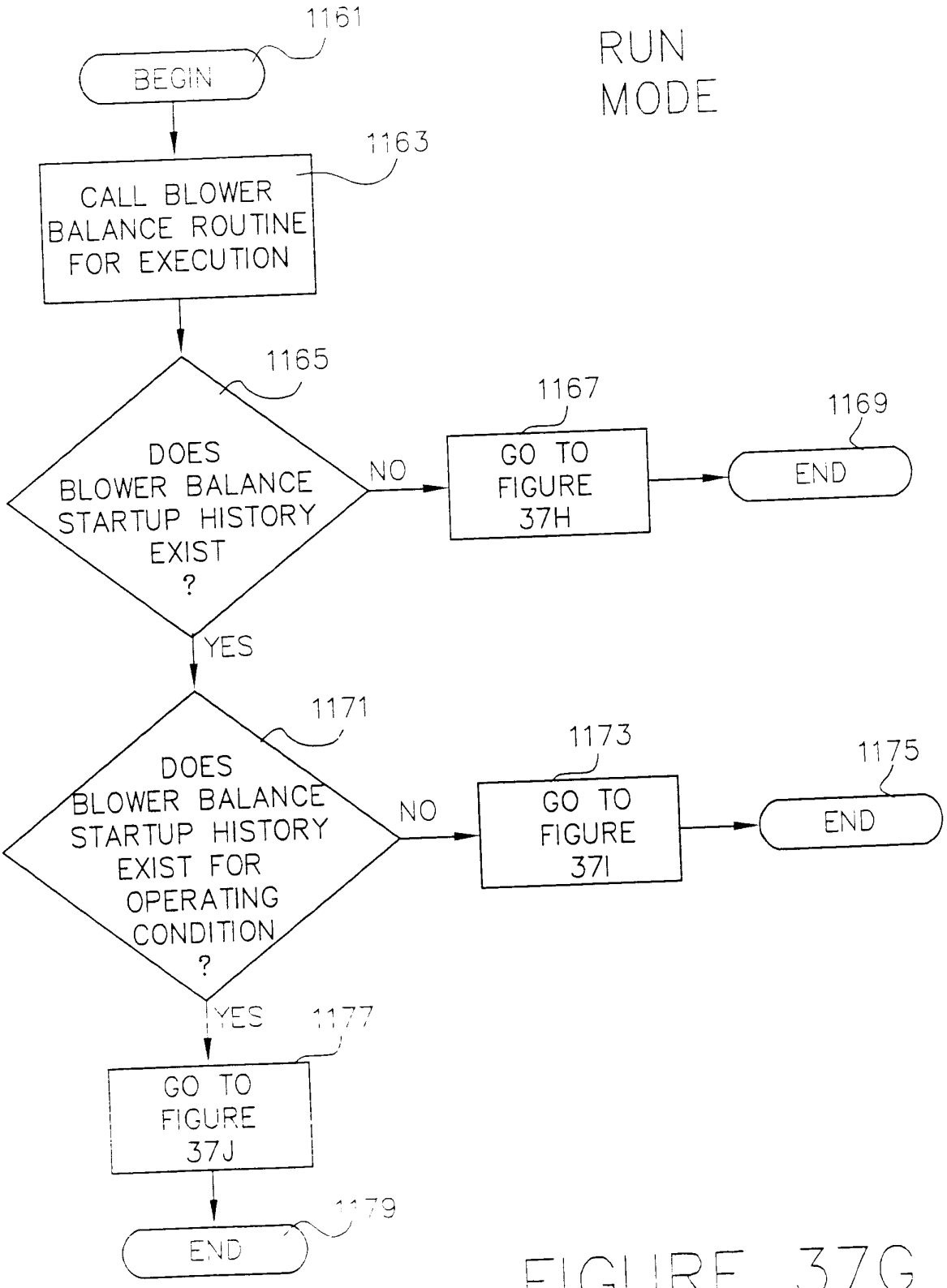

RUN MODE
1161
BEGIN
1163
CALL BLOWER BALANCE ROUTINE FOR EXECUTION
1165
DOES BLOWER BALANCE STARTUP HISTORY EXIST ?
NO
1167
GO TO FIGURE 37H
1169
END
YES
1171
DOES BLOWER BALANCE STARTUP HISTORY EXIST FOR OPERATING CONDITION ?
NO
1173
GO TO FIGURE 37I
1175
END
YES
1177
GO TO FIGURE 37J
1179
END

FIGURE 37G

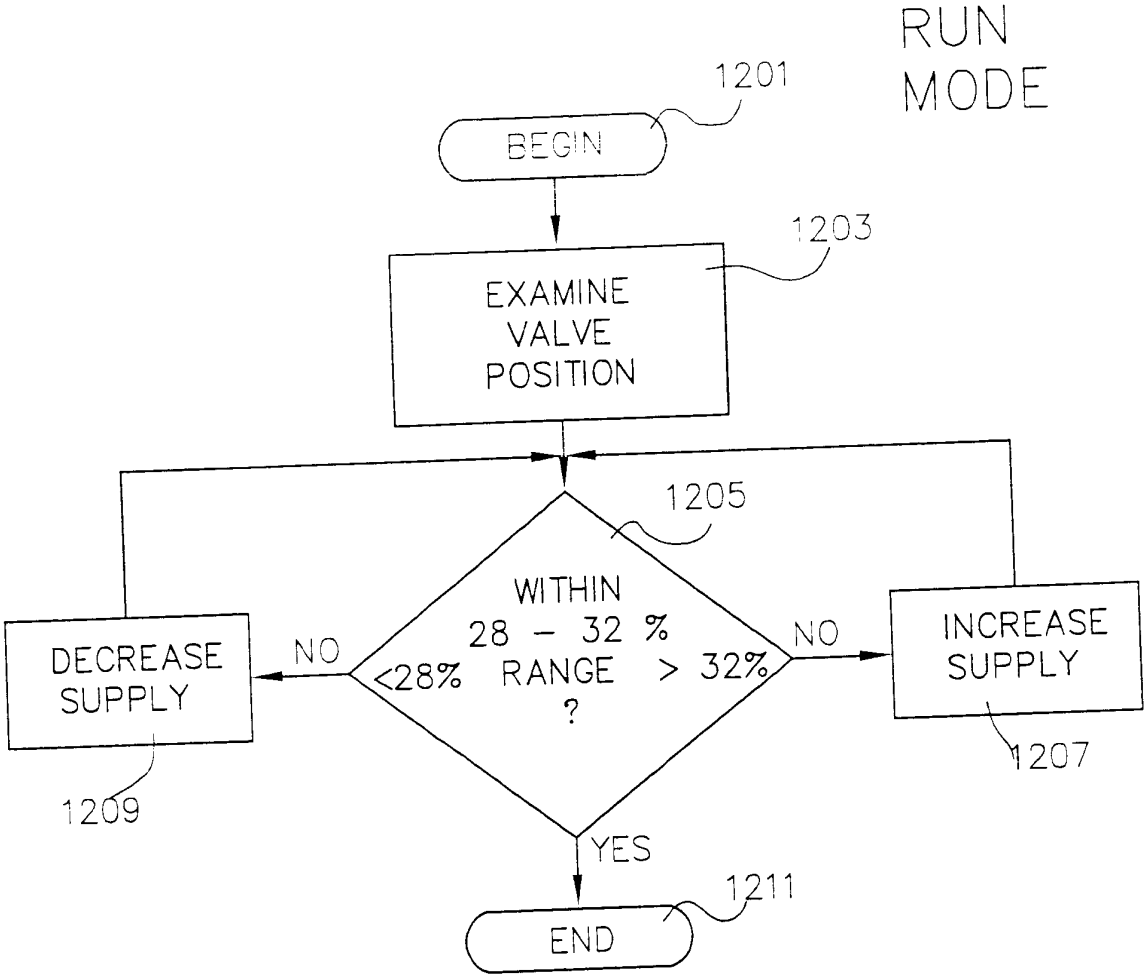

RUN
MODE
1201
BEGIN
1203
EXAMINE
VALVE
POSITION
1205
WITHIN
28 – 32 %
<28% RANGE > 32%
?
NO
NO
DECREASE
SUPPLY
INCREASE
SUPPLY
1209
1207
YES
1211
END

FIGURE 37H

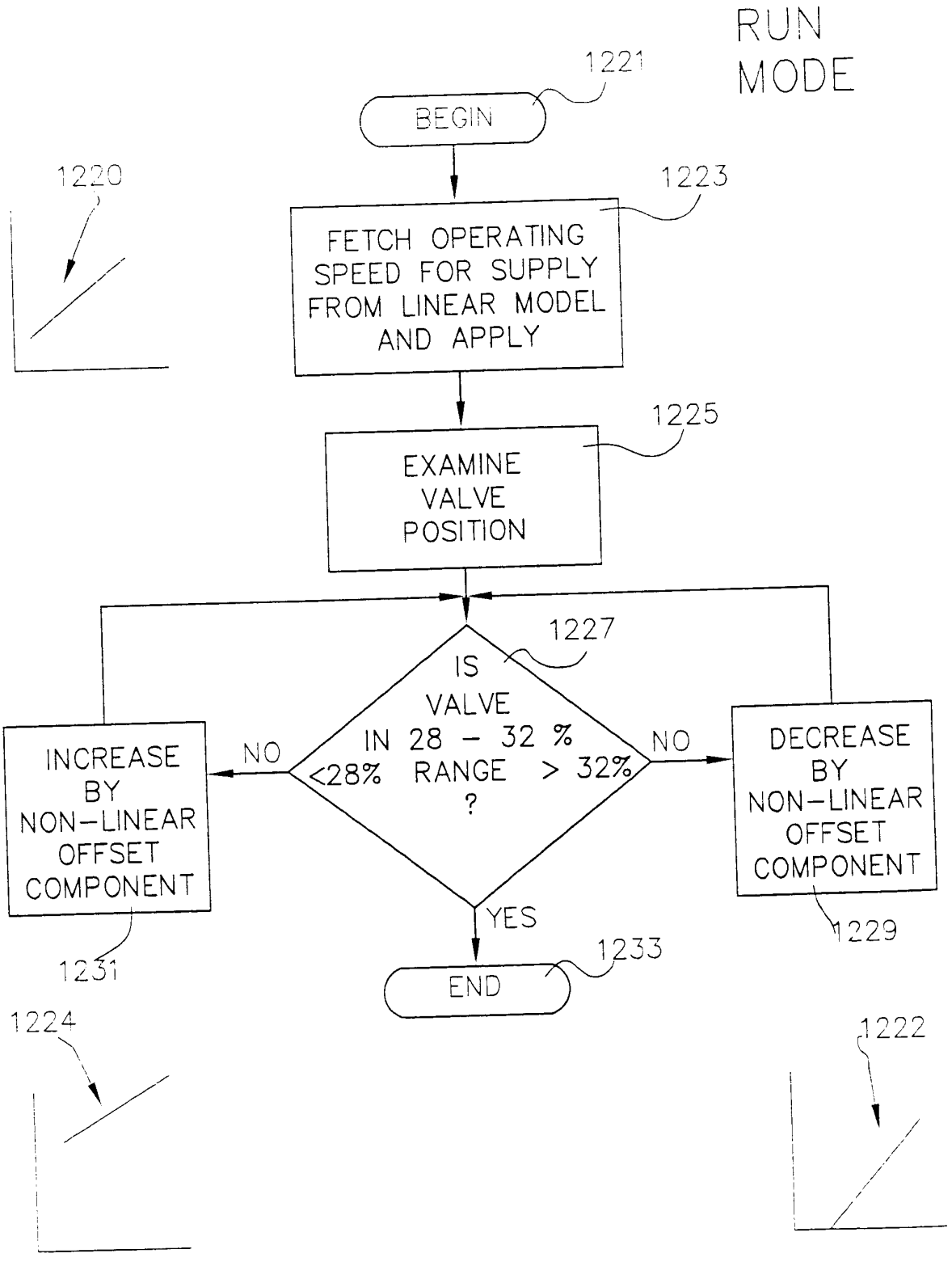

RUN MODE
1221
BEGIN
1220
1223
FETCH OPERATING SPEED FOR SUPPLY FROM LINEAR MODEL AND APPLY
1225
EXAMINE VALVE POSITION
1227
IS VALVE IN 28 - 32 % <28% RANGE > 32% ?
NO
NO
YES
INCREASE BY NON-LINEAR OFFSET COMPONENT
DECREASE BY NON-LINEAR OFFSET COMPONENT
1231
1229
1233
END
1224
1222

FIGURE 371

RUN MODE

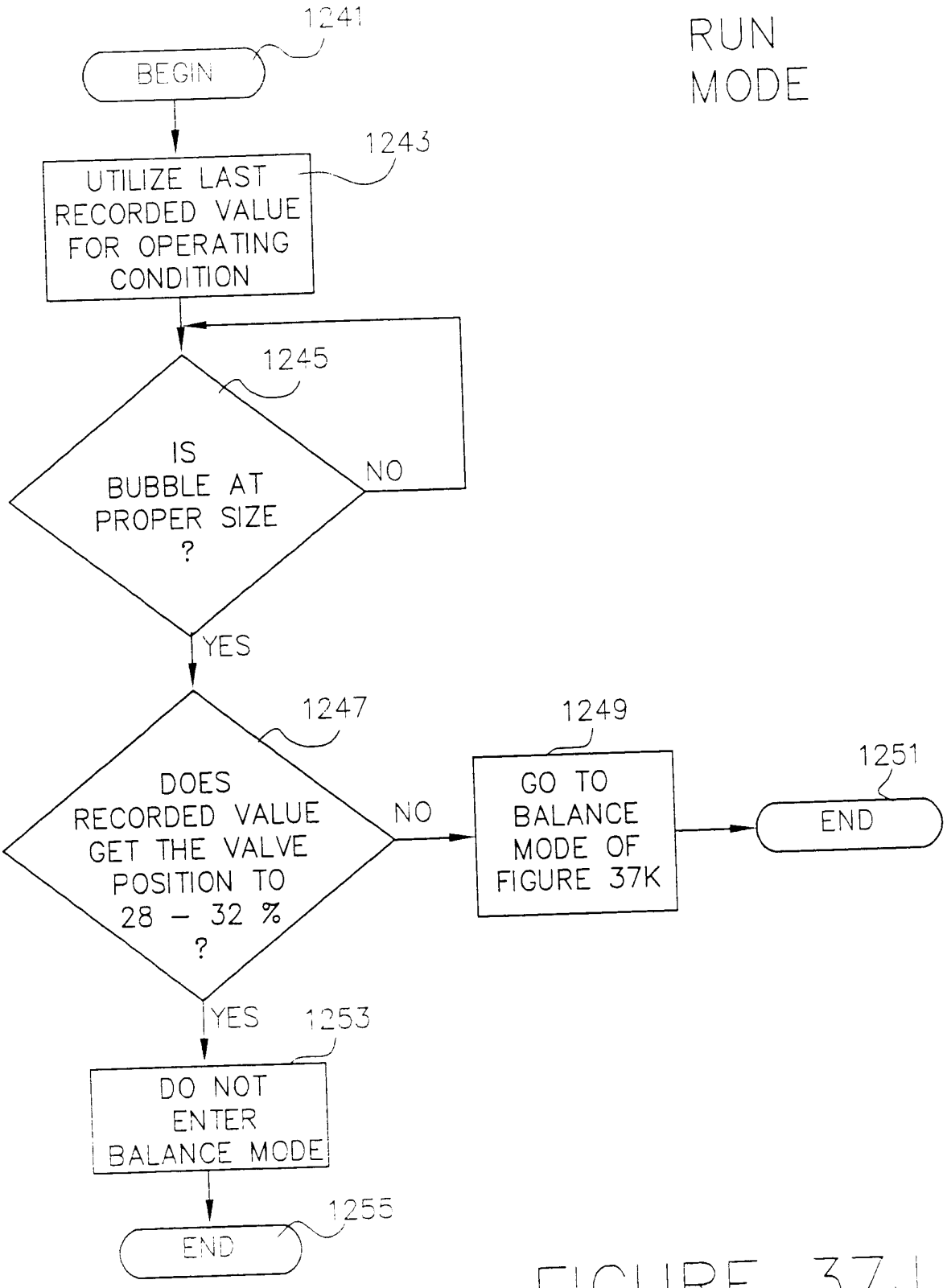


FIGURE 37J

BALANCE MODE

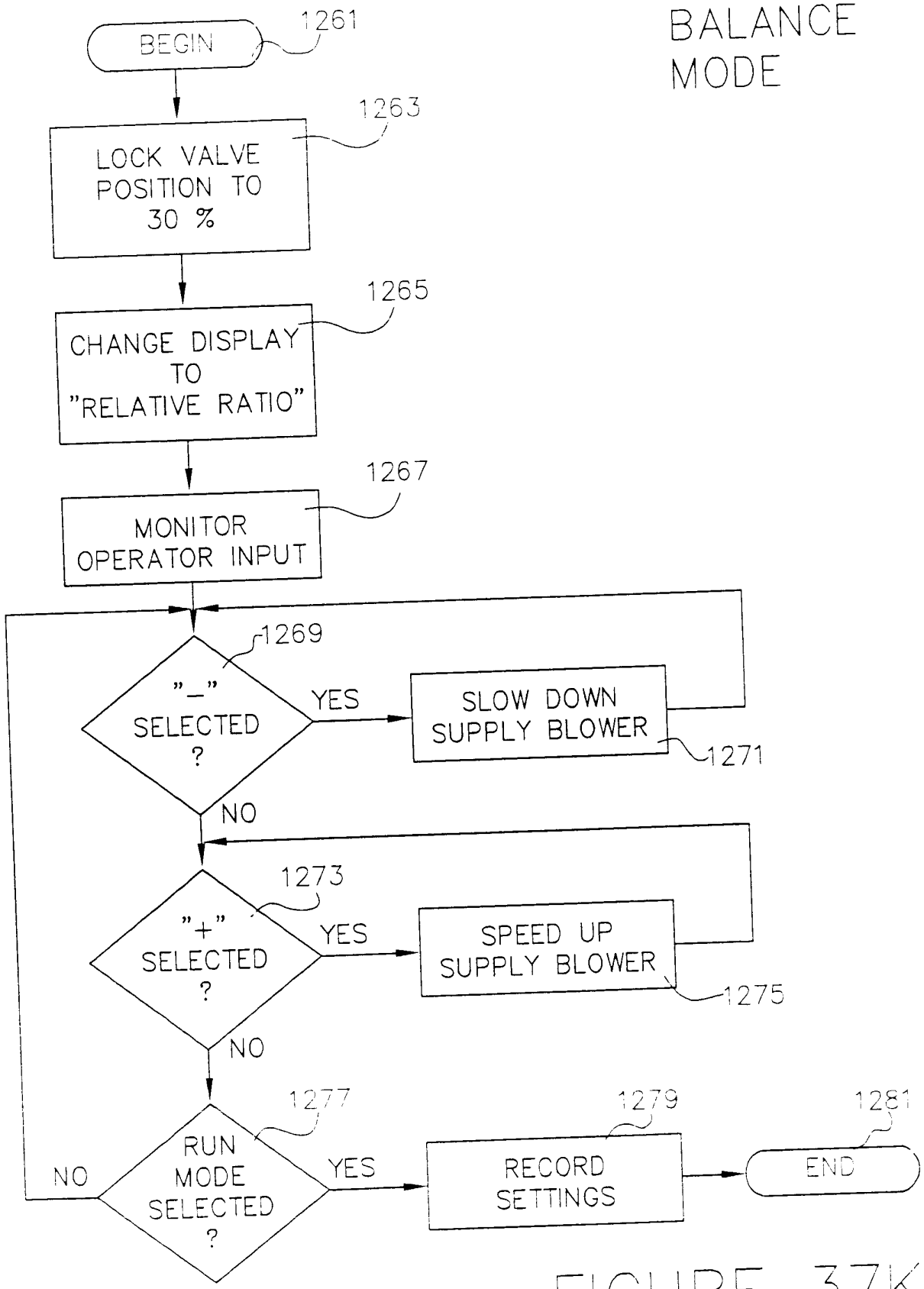


FIGURE 37K

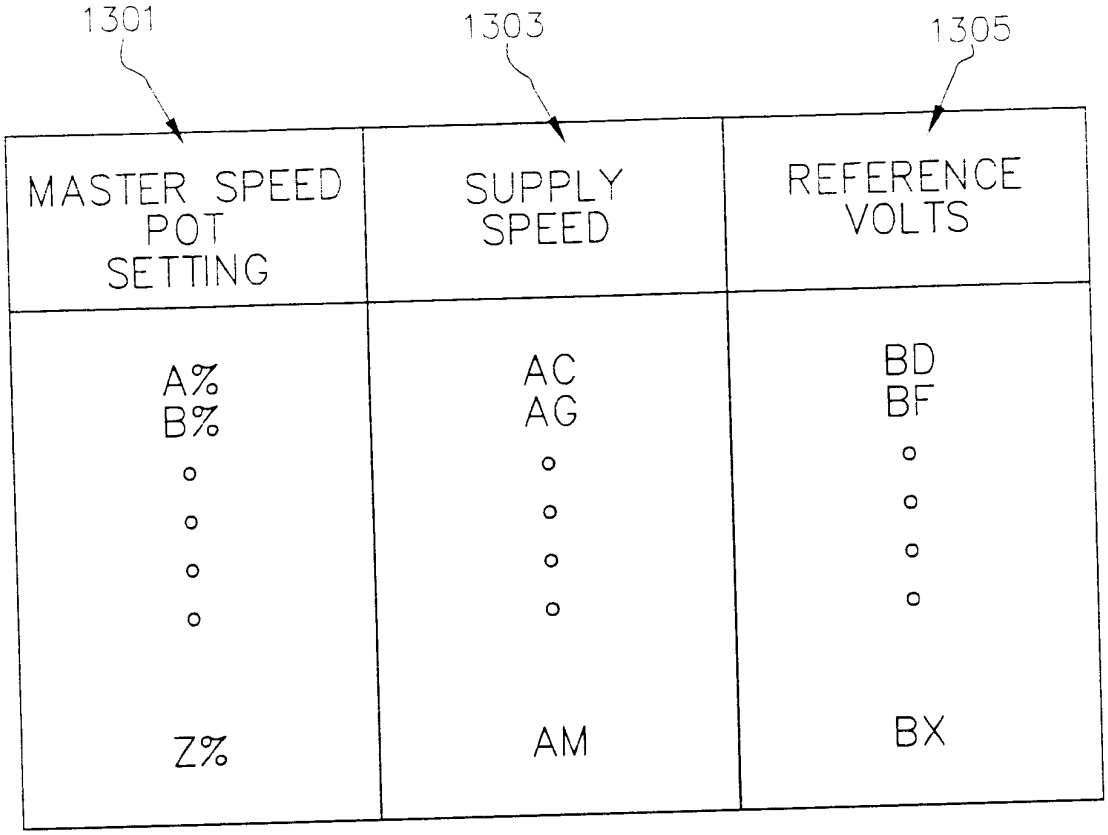

1301
1303
1305
MASTER SPEED POT SETTING
SUPPLY SPEED
REFERENCE VOLTS
A%
B%
Z%
AC
AG
AM
BD
BF
BX

FIGURE 37L

BUBBLE
BREAK
DETECTOR

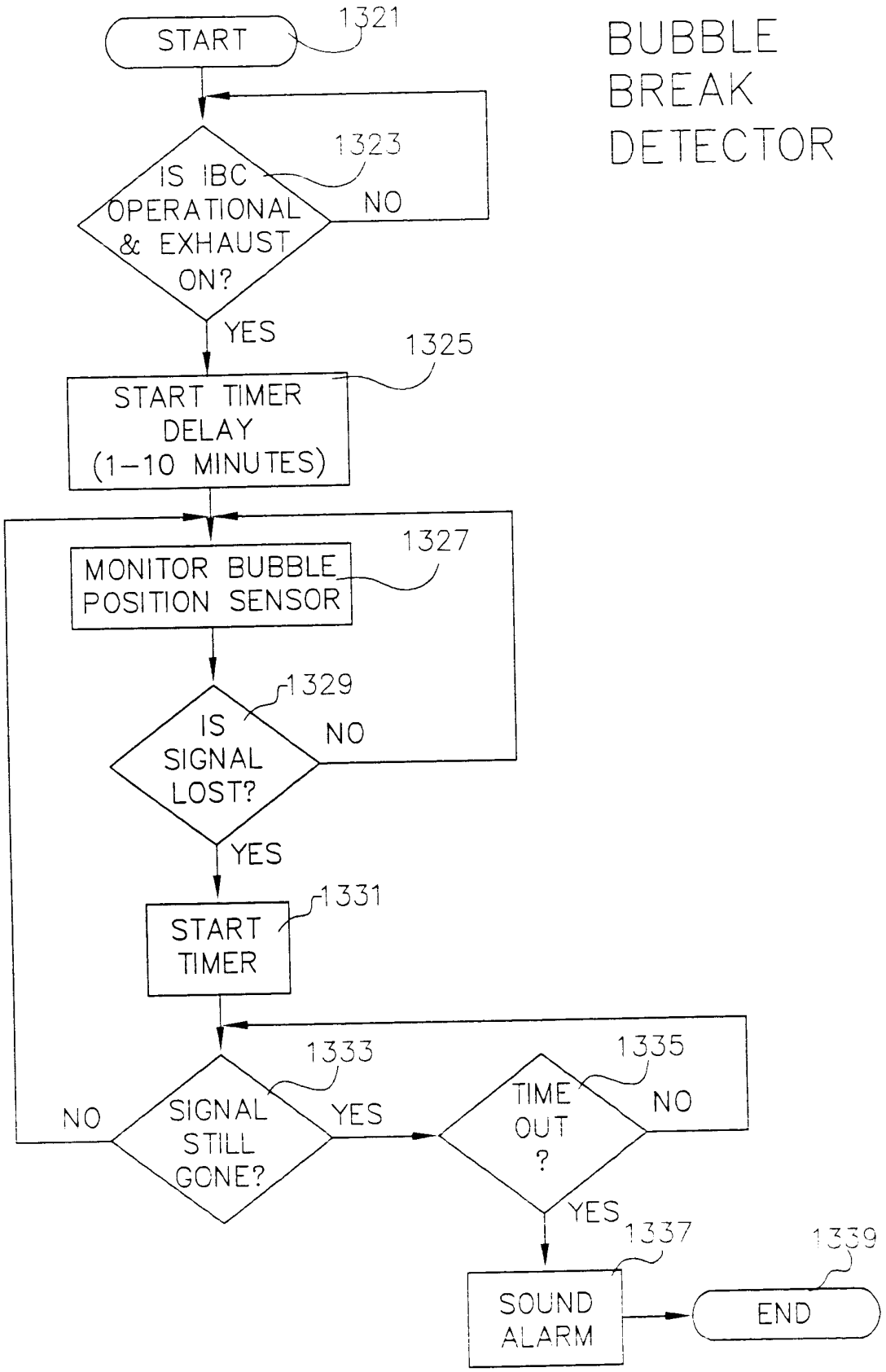


FIGURE 37M